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SCHWAGERINA VERSUS *PSEUDOSCHWAGERINA* AND *PARASCHWAGERINA*

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ABSTRACT

This paper presents the first critical study, based upon sections, of the genotype of *Schwagerina*. Ehrenberg's original types of *Borelis princeps* are quite different from the form now commonly identified as *Schwagerina princeps*.

The genus *Schwagerina* is redefined in accordance with its genotype, taking the place of *Pseudofusulina*, which is suppressed as a synonym.

The inflated fusulines with a tightly coiled juvenarium, currently identified as *Schwagerina*, are left without a name. Two independent tribes are here recognized and for these the generic names *Pseudoschwagerina* and *Paraschwagerina*, respectively, are proposed.

INTRODUCTION

The fusuline genus *Schwagerina* has commanded great interest of recent years as an index to the Lower Permian formations, and the "zone of *Schwagerina*" is now recognized throughout the Northern Hemisphere. Unfortunately, the genus was based upon types that were never sectioned and have not been restudied since the brief original description of *Borelis princeps* by Ehrenberg almost a hundred years ago. These types are still preserved in the collections of the Geological-Paleontological Institute at the University of Berlin and, through the good offices of Dr. Otto H. Schindewolf and the kindness of Dr. W. O Dietrich, have been entrusted to us for study. For this privilege we are deeply grateful.

The structure of the genotype proves to be quite different from that now associated with the name *Schwagerina* and it is, therefore, necessary to redefine the genus in accordance with its genotype and to find a new name for the forms now known as *Schwagerina*.

THE GENOTYPE OF *SCHWAGERINA*

In 1877 (4, p. 143) Von Möller redefined *Fusulina*, the only fusuline then recognized, and proposed three new genera, *Schwagerina*, *Hemifusulina* and *Fusulinella*. The last two were based on the peculiar structure of the wall or the septa, and the first two were separated on general form, *Fusulina* embracing the slender or subcylindrical species and *Schwagerina* the globular and thickly fusiform types. Later it was observed that some of the latter possessed tightly coiled juvenile whorls followed by an abrupt inflation. Eventually this tightly coiled juvenarium came to be considered the diagnostic feature of *Schwagerina*.

No species were described at the time of the generic diagnosis, but the genotype was designated in the following words: "Als eine typische

Form derselben sehe ich die *Borelis princeps* Ehrenb. an.[6]" The footnote reads: "Ehrenb.: zur Mikrogeologie, 1854, tab. XXXVII, X, C, figs. 1–4." In the discussion Möller indicated that he would include also in this genus *Fusulina robusta* Meek, *Borelis spheroidea* Ehr. and *Borelis hoeferi* Stache. The two last species he later transferred to *Fusulinella* and it is improbable that he had seen Meek's species. The original diagnosis, in any event, clearly fixed the genotype of *Schwagerina* as *Borelis princeps* Ehrenberg.

The original description of this species was given before the Prussian Academy in 1842, when Ehrenberg reported on a few specimens of fossiliferous "Mountain limestone" brought back from Russia by Keyserling and Blasius and by Helmersen. The types of *Borelis princeps* were in a piece of cherty limestone secured by von Helmersen in Pinega Valley, Archangel. Ehrenberg's description (2, p. 274) consisted of two sentences only, as follows: "Eine dritte, weit grösere Art, welche 2 Linien im Durchmesser hat, entheilten die von Herrn. v. Helmersen übersandten Hornsteine des Bergkalks, aber verkieselt. Diese Art wird als *Borelis Princeps* bezeichnet." The illustrations appeared, without text, twelve years later in Ehrenberg's Mikrogeologie. On Plate 37 of this great volume, Ehrenberg grouped figures of 15 unrelated collections, designating each group by a Roman numeral. Of these, group X bears the legend, "Melonien- und Alveolinen-Bergkalk von Russland," with a bibliographic reference to the paper of 1842. This group includes four independent lots, labeled A to D respectively, and of these C bears the legend, "Melonien- und Alveolinen-Hornstein des Bergkalks der Pinega (Dwina), Archangel. Helmersen. Massenansicht." This group, reproduced as figure 1 in our Plate 10, shows a view of one end of the piece of stone and six individual figures of the contained fossils. These are labeled as follows:

FIG. 1—*Borelis princeps*, natürl. grösse
2–4—*Borelis princeps*, 4 mal vergr.
5—*Alveolina montipara*
a. naturl., b. 4 mal vergr.

It is clear, therefore, that the illustrated material is that upon which the species was based. The authenticity of the material before us cannot be questioned for it has been preserved at Berlin with Ehrenberg's collection and is labeled as the types of the species. Moreover, the general view of the specimen shown in Ehrenberg's figure C can be certainly identified as a part of one end of the specimen before us, as shown in figures 1 and 2 of our Plate 10. It is almost certain that Ehrenberg's figures 1 to 3 are reconstructions from the shells standing in relief on the upper surface of the rock. This may be inferred because there are no free specimens now preserved, and in the original description Ehrenberg spoke only of a piece of hornstone which included the specimens. It would be impossible to free specimens from this cherty matrix and, moreover, there were no toolmarks upon it. Figure 4, showing a cross

section, is too crude to identify with certainty, but appears to be a mirror reflection of a natural section exposed on the broken face of the rock.

The study of this material has presented exceptional difficulties. Fortunately the rock is filled with specimens, over 100 of which appear on its surfaces, but it is entirely silicified and the shell walls have largely taken on a glassy clearness. They are partially covered with microscopic spherules of silica apparently deposited before the wall was replaced. These appear opaque in the sections, and in places help to outline the surface of the wall, which is otherwise indistinct, though in the inner volutions they tend to obscure the details. Because of the historical significance of this small specimen, we have taken great pains to remove a portion for sectioning without damaging the upper surface which shows several specimens in relief, or marring the end that was figured by Ehrenberg. We have prepared 18 thin sections, of which 11 are axial and 7 sagittal. All of these cut the proloculum, but in several the preservation is not good at the center.

It is evident from our sections that *S. princeps* and *S. montipara* are closely allied, if not merely extremes of one species. Ehrenberg based the latter on the most slender type in the rock and the former on the most gibbous. Without making sections or giving the material critical study, he did not consider the probable relations of these forms.

To document our investigation, we have numbered the specimens we have studied. Of these 1 to 6 are still in the stone and 7 to 24 are thin sections. Specimens 1 and 3 and slides 7, 9, 16, 18 and 24 are considered types of *Schwagerina princeps*, while specimens 2,4,5 and 6 and slides 8, 10–15, 17 and 19 are regarded as types of *S. montipara;* slides 20 to 23 are doubtful. To clarify the matter we are recognizing and redescribing both species. Without exception, our thin sections indicate a gradual, though rather rapid, expansion of the volutions with no strong inflation and no distinct juvenarium. The following generic and specific descriptions are based on this type material.

Genus SCHWAGERINA Möller, 1877

Schwagerina MÖLLER, Uber Fusulinen und ähnlichen Foraminiferen-Formen des russischen Kohlenkalkes: Neues Jahrb., Jahrgang 1877, p. 143.

Diagnosis.—Fusiform to subcylindrical fusulines with a spiral wall composed of tectum and well-defined keriotheca; volutions bilaterally symmetrical and expanding gradually; median tunnel well defined but chomata lacking, or rudimentary and confined to the innermost whorls; septa strongly and regularly fluted so that opposed folds of adjacent septa meet near the base, subdividing the lower part of the meridional chambers into rounded chamberlets.

Genoholotype, *Borelis princeps* Ehrenberg.

Synonyms, *Fusulina* (part) of authors, *Pseudofusulina* Dunbar and Skinner.

Homonyms, *Schwagerina* Möller, 1878 [non 1877], *Schwagerina* Schwager, 1883, and of later authors.

Discussion.—The misunderstanding of this genus sprang from Möller's second fusuline study. In 1878 he published his "Spiralgewundenen Foraminiferen des russischen Kohlenkalks." Here he re-

described *Schwagerina princeps*, basing his study not on the original types but on material from Timan Plateau, some 200 miles from Helmersen's locality. Schwager, in 1883, followed this interpretation and redescribed *S. princeps* from material collected by Von Richtofen near Shanghai, China. His excellent figures, showing tightly coiled inner whorls followed by great inflation of the succeeding volutions, did much to crystallize the current conception of *S. princeps* and of the genus *Schwagerina*. But, unfortunately, his material, like that of Möller, differs greatly from the types described by Ehrenberg.

Although the genotype is a thickly fusiform species, we cannot accept external form alone as a generic character. The essential characters are (1) the structure of the wall, (2) the gradual expansion, (3) the plan of septal fluting, and (4) the lack of chomata. The many known species having these characters in common, constitute a single genetic tribe ranging in external form from thickly fusiform to nearly subcylindrical; any separation on the basis of form would be purely arbitrary; all must be embraced in the genus *Schwagerina*.

SCHWAGERINA PRINCEPS (Ehrenberg)

Plate 10, figures 1–11

Borelis princeps EHRENBERG, *1842*, Berichte K. preuss. Akad. Wiss., p. 273; *1854*, Mikrogeologie, pl. 37, figs. X, C and C 1–4.

Fusulina krotowi SCHELLWIEN, *1908*, Palaeontographica, vol. 55, p. 190, pl. 20, figs. 1–10.

Description.—Small, thickly fusiform or subglobular shells of 6 to 6½ volutions, attaining a length of about 4.0 to 5.5 mm. and a diameter of 2.5 to 3.5 mm., the ratio of breadth to length ranging from about 1:1.25 to 1:1.5. The polar extremities tend to be subacute in the younger whorls and bluntly rounded at maturity.

The proloculum has a diameter of 160

EXPLANATION OF PLATE 10

FIGS. *1*—Original illustrations of *Borelis princeps* Ehrenberg and *Alveolina montipara* Ehrenberg, after Ehrenberg. C, view of part of the Helmersen specimen, natural size; *1*, *Borelis princeps*, natural size; *2–4*, *Borelis princeps*, ×4; *5–6*. *Alveolina montipara*, natural size and ×4. (p. 86)

2—Photograph of one end of the Helmersen specimen, natural size. The distribution of the fusulines and the relative lightness and darkness of each shows clearly that it was a part of this surface which was illustrated by Ehrenberg. If the Ehrenberg figure C be rotated about 30° to the left in a counter-clockwise direction the correspondence will be clear. (p. 86)

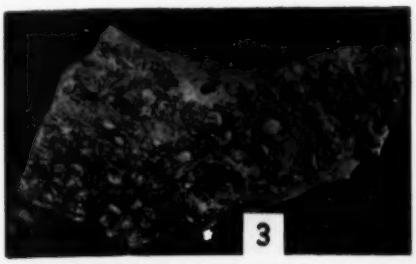
3—Upper surface of the Helmersen specimen showing the types of *Borelis princeps* in relief, natural size. None of these specimens is fully exposed. The larger shells actually agree closely in size with Ehrenberg's figure C_1. (p. 86)

4–5—*Borelis princeps*, adult and young specimens (specimens 1 and 3), ×10. These are on the upper surface of the Helmersen specimen. (p. 86)

6—An immature specimen tentatively referred to *Alveolina montipara* (specimen 2), ×10. (p. 86)

FIGS. *7–11*—*Borelis princeps*. *7*, *8*, Two views of a single specimen, ×10. This individual was first excavated into relief on the upper surface of the Helmersen specimen and found to agree in gibbosity with the type illustration. It was then sectioned. Fig. *7* shows a tangential polished surface cutting the penultimate whorl and showing the plan of septal fluting which leaves the chambers subdivided into cell-like chamberlets. Fig. *8* shows an axial section of the same. The innermost volutions are altered to clear quartz and do not show plainly (specimen 24). *9*, Axial section of specimen 7, ×10. The inner volutions are darkened and partly obscured by microscopic secondary spherules of quartz. *10*, *11*, Sagittal sections of specimens 16 and 18, respectively, ×10. The former just touches the proloculum. (p. 86)

12–14—*Alveolina montipara* Ehrenberg (×10). *12*, Enlarged view of specimen 4, weathered into partial relief. This individual, on the upper surface of the Helmersen specimen, is believed to be the one illustrated by Ehrenberg as figure C, 5 and 6 (holotype). *13*, A paratype (specimen 5) seen as a polished axial surface, ×10. *14*, Sagittal section of a paratype (specimen 17), ×10. (p. 87)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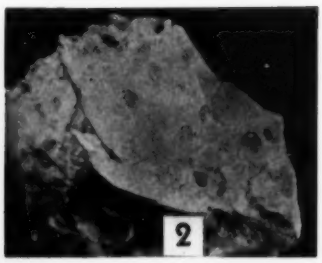
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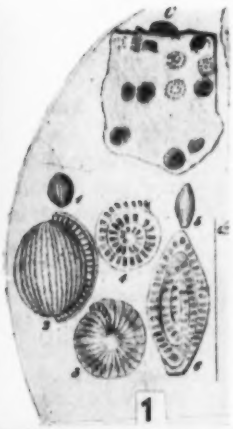
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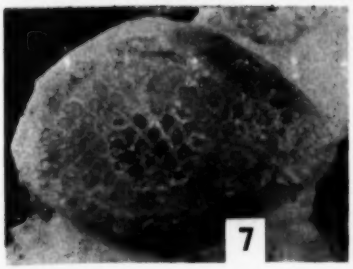
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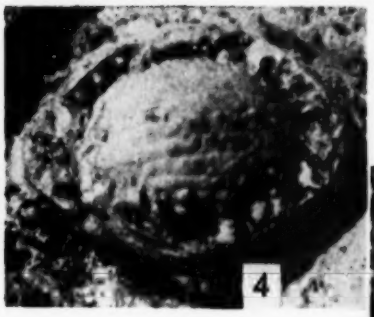
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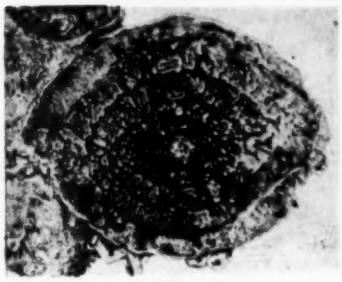
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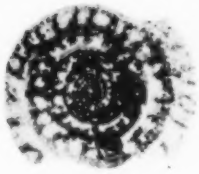
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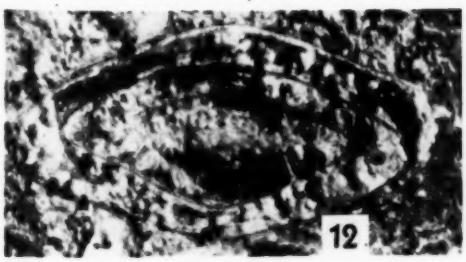
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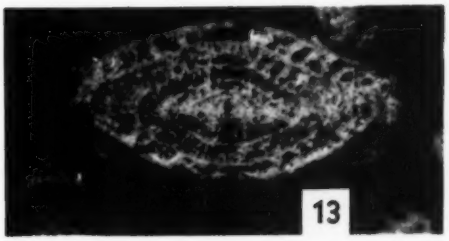
13

Dunbar and Skinner, Permian Fusulinids

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microns in slide 9 where it can be measured accurately. It measures only 120 microns in slide 18, a sagittal section. In slides 24 and 7 it appears to be 230 and 220 microns, respectively, but is too obscure for satisfactory measurement. The expansion of the whorls in the sagittal plane is gradual but rapid, as shown in the table below.

The tunnel angle is generally between 20° and 30° and does not widen notably in the outer whorls. It measures about 30° in the third and fifth volutions of section 7 but appears to be only 19° in the fourth volution. In section 9 it measures 29° in the third and 26° in the fifth volution. In section 24 it is not wider than 20°. Chomata appear to be completely lacking.

The spiral wall increases gradually in thickness, attaining a maximum of about 80 microns in the outer whorls. In spite of the replacement by silica, a well-developed keriotheca and tectum are visible in many places.

The septa are intensely and regularly fluted, as may be seen in broken shells (Pl. 10, figs. 4 and 5) and in tangential sections (fig. 7). The septa are so spaced that opposed folds of adjacent septa touch, dividing the lower part of the meridional chambers into regular cell-like chamberlets.

The septa number ?, ?, 16, 21, 28 and 33, respectively, in the six volutions of specimen 16, and 11, 16, ?, 21, 28 and 27 in specimen 18.

The following table gives statistical data for specimens 24, 9, 7 and 18. At the left, the proloculum is numbered 0 and the volutions following are numbered in order. Wherever measurements could not be satisfactorily made, the appropriate place in the table is left blank.

Discussion.—*Fusulina krotowi* Schellwien appears to be a synonym of this species. The excellent original illustrations of that species, as well as the text, show essential agreement with the types of *S. princeps*, not only in shape and size, but in the size of the proloculum, the rate of expansion, width of tunnel, septal count, and character of septal fluting.

Occurrence.—The precise locality and horizon of the type material is unknown. The label with the specimen agrees with Ehrenberg's statement that it was collected from the "Bergkalk" in the Pinega Valley, province of Archangel. The horizon is undoubtedly Uralian or Artinskian. Schellwien indicated that his *Fusulina krotowi* occurs in the Schwagerinenkalk.

SCHWAGERINA MONTIPARA (Ehrenberg)

Plate 10, figures 12–14

Alveolina montipara EHRENBERG, *1854*, Mikrogeologie, pl. 37, X, C, 5–6 and plate legend.

Description.—A small, fusiform species of 6 or 7 volutions, attaining a length of about 5.5 mm. and a diameter of 2.6 mm., the length being about twice the diameter and the axial profile almost an even ellipse.

This species differs from *S. princeps*

Table of Measurements

Half length				Half diameter					Form ratio		
Vol.	24	9	7	24	9	7	18	16	24	9	7
0				0.115	0.080	0.110	0.060	?			
1				0.165	0.14	0.230	0.140	0.170			
2		0.25		0.280	0.21	0.370	0.220	0.270			
3		0.65	0.9	0.460	0.33	0.630	0.350	0.470			1.4
4	0.9	1.10	1.5	0.675	0.53	1.04	0.530	0.770	1.33	2.0	1.4+
5	1.5	1.4	2.1	1.035	0.84	1.47	0.830	1.15	1.4	1.7	1.4
6	2.0	1.9	2.8	1.45	1.24		1.24	1.53	1.38	1.5	
7				1.78			1.62				

chiefly in being relatively more slender, and it is not improbable that with abundant free specimens it could be shown that the two intergrade, and *S. montipara* is only a more slender variety of *S. princeps*.

The proloculum has a diameter of 160 microns in specimen 5, 180 in specimen 10, and 170 in specimen 8.

The tunnel angle is between 25° and 35°, measuring 25° in the fourth volution of specimen 5, 30° in the sixth, and 34° in the seventh. Chomata are lacking and the septa are intensely and regularly fluted, the folds extending well up toward the outer wall and meeting those of adjacent septa so as to divide the longitudinal chambers into regular, cell-like chamberlets. The septal count in the first four volutions of specimen 19 runs 11, ?, 17, 22, and in seven volutions of specimen 17 it is 12, 13, 18, 20, ?, 22, 23. In specimen 14 the septa of the inner volutions cannot be counted but the outer ones have 32 and 34 septa, respectively.

The spiral wall consists of tectum and well-defined keriotheca as in *S. princeps*. fect polished axial surface. It has proportions identical with specimen 4 and is so well preserved that precise measurements can be taken, even to the diameter of the proloculum. In addition, one specimen has been developed into high relief and nine are represented by thin sections.

Möller (5) started an erroneous conception of this species when, without sectioning the type material, he applied the name *Fusulina montipara* to his own material gathered from numerous localities. His only figured axial section shows a shell with very heavy chomata and slightly fluted septa—a typical *Triticites*. Schellwien (1908) followed him in this regard, reproducing Möller's figures. It is probable that references to the species later than 1880, depending on Möller's interpretation instead of a study of authentic material, are all misidentifications.

Distribution.—Original types on same piece of chert as those of *S. princeps*. This form was probably included in *Fusulina krotowi* by Schellwien. His types came from the Schwagerinenkalk.

Table of Measurements

Vol.	Half length			Half diameter			Form ratio		
	5	10	8	5	10	8	5	10	8
0	0.08			0.08	0.09	0.085			
1	?			0.12	1.4	0.13			
2	0.35			0.19	0.23	0.18	1.8		
3	0.65			0.28	0.34	0.32	2.3		
4	1.0	1.1	1.1	0.43	0.52	0.46	2.3	2.1	2.4
5	1.5	1.8	1.3	0.64	0.83	0.71	2.4	2.1	1.8
6	2.2	2.3	1.9	0.98	1.2	0.99	2.2	1.9	1.9
7	2.8		2.4	1.33		1.37	2.1		1.75

Discussion.—Ehrenberg's original figure of this species represents a specimen of slender fusiform shape, naturally weathered to show an axial section of the two outer whorls with the inner volutions lying at the center in relief. The septa are strongly fluted. These are exactly the features shown by the specimen we have numbered 4 and which is, therefore, regarded as the holotype (Pl. 10, fig. 12). We have developed specimen 5 to a per-

SCHWAGERINA of authors (not Möller)

For the species so long mistaken for *Schwagerina*—those characterized by a tightly coiled juvenarium followed by highly inflated whorls—no other name has ever been used, doubtless because the misconception was started and crystallized at an early date.

The several species concerned fall

naturally into two groups of independent origin, one having developed out of *Triticites* and the other out of *Schwagerina* s.s. Since their common characters are due to convergence rather than close relationship, they should not be embraced in a single genus. We, therefore, propose two new genera and group the described species as follows:

PSEUDOSCHWAGERINA

Schwagerina amedaei Deprat
Schwagerina fusiformis Krotow
Schwagerina fusulinoides Schellwien
Fusulina muongthensis Deprat
Schwagerina princeps Schwager, Lee, Chen, etc. [not Möller]
Fusulina robusta Meek
Schwagerina uddeni Beede and Kniker

PARASCHWAGERINA

Schwagerina alternans Schellwien
Fusulina dussaulti Deprat
Schwagerina fosteri Thompson and Miller
Schwagerina gigantea White
Schwagerina kansasensis Beede and Kniker
Schellwienia oblonga Ozawa
Schwagerina tinvenkiangi Lee
Schwagerina yabei Staff

There are a few remaining species too poorly described to be certainly placed, and some undescribed species which will represent each group.

Genus PSEUDOSCHWAGERINA Dunbar and Skinner, n. gen.

Diagnosis.—Thickly fusiform to subspherical fusulines; wall consisting of tectum and keriotheca; inner volutions closely coiled to form a compact juvenarium of 2 to 5 whorls; succeeding volutions high and strongly inflated, the last declining again in height; a single low median tunnel is present; chomata are well marked in the juvenarium but rudimentary or lacking in the inflated whorls; septa rather feebly and irregularly fluted, the folds being largely restricted to the part near the basal margin. In some species the septa are almost plain; in all they are so widely spaced that opposed folds of adjacent septa do not normally touch.

Genotype, *Schwagerina uddeni* Beede and Kniker.
Synonym, *Schwagerina* (part) of authors (not Möller).

Discussion.—In this genus the proloculum is commonly large, and the whorls of the juvenarium are relatively short and thickly fusiform (Pl. 11, figs. 6 and 7). In some species, however, as the Chinese form identified by Schwager as *S. princeps*, the proloculum is less than 100 microns in diameter and the juvenile whorls accordingly are relatively more slender and thin-walled. In these, however, the septa are but slightly fluted and the chomata, though slender, persist into the adult whorls.

It seems appropriate that this group of species so long mistaken for the real *Schwagerina* should bear the name *Pseudoschwagerina*.

Genus PARASCHWAGERINA Dunbar and Skinner, n. gen.

Diagnosis.—Thickly fusiform to subspherical fusulines; wall consisting of tectum and keriotheca; proloculum very small (in all known species less than 100 microns in diameter); inner volutions slender, elongate and very closely coiled, forming a well-defined juvenarium of 2 to 5 volutions, succeeding whorls strongly inflated and high, the last declining somewhat again; septa with high, strong folds; chomata inconspicuous or lacking even in the juvenarium, and normally completely absent in the inflated whorls.

Genotype, *Schwagerina gigantea* White.
Synonym, *Schwagerina* (part) of authors (not Möller).

Discussion.—In this genus the septal folds are marked even in the juvenarium (Pl. 11, figs 2 and 5), and in the adult whorls are commonly so strong that opposed folds of adjacent septa touch at the base, subdividing the lower part of each

meridional chamber into chamberlets (Pl. 11, figs 3 and 4). In axial sections high, narrow septal loops are abundant. Most of these species are thickly fusiform, but *P. yabei* (Staff) and *P. kansasensis* (Beede and Kniker) are more strongly inflated and almost spherical.

The ontogeny shows that this group of species developed out of *Schwagerina*, which is marked by strong septal folds and rudimentary chomata. From *Schwagerina* it differs only in a rather abrupt inflation, instead of a gradual expansion, after the formation of the juvenile whorls.

Paraschwagerina contrasts with *Pseudoschwagerina* in having strongly fluted instead of nearly plane septa, and in the more rudimentary condition of its chomata. The latter are well marked in the juvenarium of *Pseudoschwagerina* and may persist feebly into the mature whorls. In axial sections the septal loops are high, narrow, and abundant in *Paraschwagerina* but low, irregular or almost lacking in *Pseudoschwagerina*.

CONCLUSIONS

The "zone of *Schwagerina*" should now be known as the "zone of *Pseudoschwagerina*." It happens, however, that the real *Schwagerina* (recently known as *Pseudofusulina*) has nearly the same stratigraphic range as *Pseudoschwagerina* and *Paraschwagerina*.

In the Mid-Continent region, *Paraschwagerina kansasensis* appears in the Neva limestone only a short distance above the first appearance of *Schwagerina*, which is represented by *S. longissimoidea* (Beede), *S. forakerensis* (Skinner) and *S. turki* (Skinner). In north-central Texas, the last two mentioned species of *Schwagerina* appear a few feet below the Saddle Creek limestone and *Paraschwagerina* appears in the Moran formation. In West Texas, *Schwagerina*, *Pseudoschwagerina*, and *Paraschwagerina* range together through the Wolfcamp, *Schwagerina* alone extending somewhat above this formation and gradually giving way to *Parafusulina* in the Leonard. In America, all three of the genera concerned mark the formations considered Lower Permian, *Schwagerina* alone extending somewhat into the Middle Permian.

In Russia, *Schwagerina* and *Pseudoschwagerina* are both abundant in the Uralian, and in China they occur together in the Chuanshan limestone, where *Schwagerina* s.s. extends upward into the Swine and Chihsia limestone, being overshadowed in the latter horizon by species of *Parafusulina* [Chen, 1934].

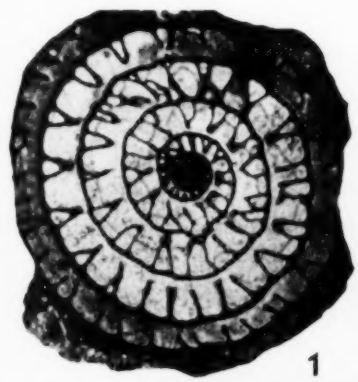
EXPLANATION OF PLATE 11

All figures ×10. Y.P.M. = Yale Peabody Museum, New Haven.

FIGS. *1–3*—*Paraschwagerina gigantea* (White). Sagittal and axial sections, and tangential slice of the penultimate whorl, the latter showing the septal fluting in plan. Wolfcamp formation, Wolfcamp Hills, Glass Mountains, Texas. Topotypes. Y.P.M. 14997, 14996. (p. 89)

4, 5—*Paraschwagerina kansasensis* (Beede and Kniker). Tangential and axial slices. Wolfcamp formation, Wolfcamp Hills, Glass Mountains, Texas. Y.P.M. 14904 and 15029. (p. 89)

6, 7—*Pseudoschwagerina uddeni* (Beede and Kniker). Sagittal and axial sections. The former shows a juvenarium of slightly less than two volutions; the latter is nearly devoid of septal loops except in the polar regions and indicates the feeble fluting of the septa in this species. The former (Y.P.M. 14917) is from the Hueco limestone, 2 miles southeast of Hueco Tanks, Texas, and the latter (Y.P.M. 14918) is from the "Basal Beds" of P. B. King near Marble Canyon, Sierra Diablo, Texas. (p. 89)



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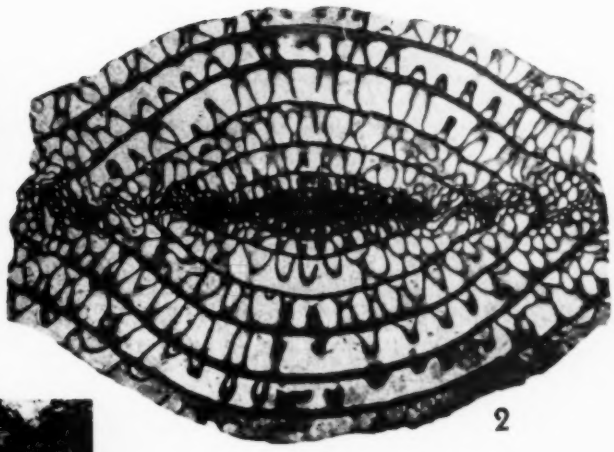

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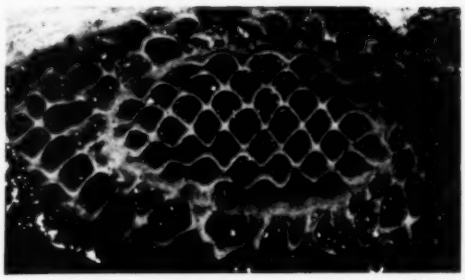

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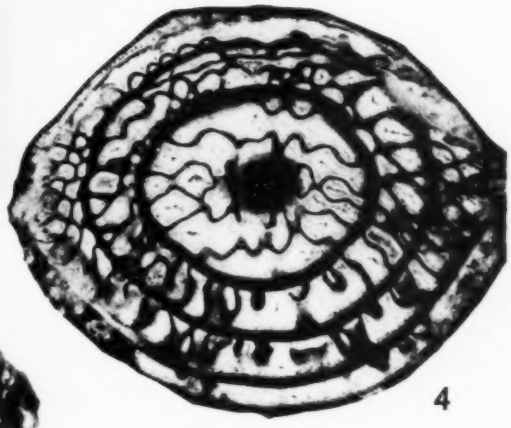

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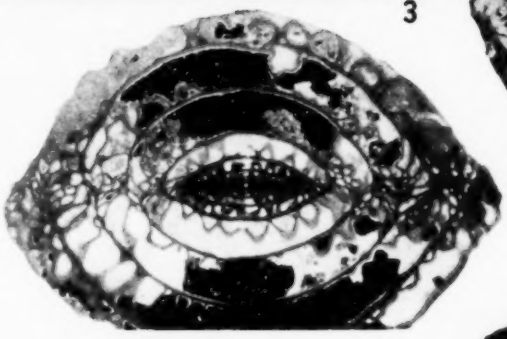

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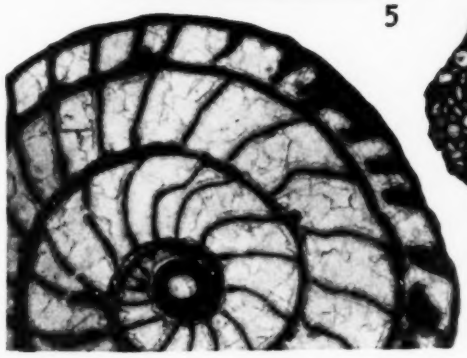

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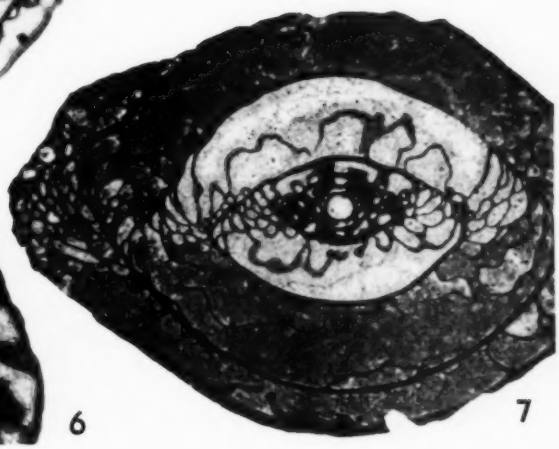

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Dunbar and Skinner, Permian Fusulinids

UNIV. OF MICH.

In the Permian of Palermo, Italy, *Paraschwagerina yabei* (Staff) and certain species of *Schwagerina* appear to occur with *Neoschwagerina* and with ammonites of Middle Permian age (6). The occurrence here is in blocks of limestone embedded in Eocene red beds and the original stratigraphic relations are unknown. Further investigation of the faunal association is needed.

The study of fusulines from precisely determined stratigraphic horizons offers one of the best bases for correlation.

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JOURNAL OF PALEONTOLOGY, VOL. 10, NO. 2, PP. 92–94, PL. 12, MARCH, 1936

ACTINOPTERYGIAN JAWS FROM THE MISSISSIPPIAN BLACK SHALES OF THE MISSISSIPPI VALLEY

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ABSTRACT

Two species of a new family of Actinopterygii from the Lower Mississippian black shales of Ohio, Kentucky, and Oklahoma are described.

The specimens described in this paper were found in the Lower Mississippian black shales of Ohio, Kentucky, and Oklahoma while collecting conodonts from these formations. The jaws were found associated with conodonts and numerous fish scales of the paleoniscid type.

The first specimen was found in 1928 in the Woodford formation in sec. 21, T. 1 S., R. 8 E., one-half mile west of Clarita, Oklahoma. After a search of many hours, five more specimens were collected from the dark-gray, somewhat fissile shales. Two other specimens from Oklahoma were found in the concretionary zone of the Woodford, in the upper third of the formation, on Sycamore Creek, sec. 27, T. 3 S., R. 4 E. In addition to the associated conodonts, a phyllocarid crustacean fauna has been described from this horizon and locality (1). Still another Oklahoma specimen was obtained from Dr. Charles E. Decker, who collected it in sec. 2, T. 2 S., R. 6 E.

Some years later additional specimens were collected from the black shales of Ohio, one from the upper part of the Cleveland shale about 3 miles south of Lake Erie near Ashmont, and another from the lower part of the Sunbury shale in central Ohio near the village of Lithopolis. During the same field season (1932) three specimens were collected in Kentucky. A fragment was found in the upper part of the Ohio shale at Farmers, on the east side of the Cincinnati arch. Two other specimens came from the Linietta (Cuyahoga) clay east of Junction City, on the southwest side of the arch. The latter formation has a concretionary zone similar to the one in the Woodford formation in Oklahoma, and it is interesting to note that the concretions yield a similar crustacean fauna.

It is unfortunate that other parts of the fish have not been discovered, as they would have greatly simplified the task of classifying these dental processes. Sir Arthur Smith Woodward was shown some of the specimens during the summer of 1933. He had opportunity for only a very few cursory examinations with the aid of a hand lens, but in his opinion the forms are new. He said that he had never observed such slender, sharp-pointed teeth from any of the Carboniferous rocks of

England, and stated that possibly the forms might be Crossopterygii. Fish belonging to this order, however, possess laniary or conical teeth in addition to the minute dentition found on the maxilla and dentary. In no instance have laniary teeth been found with the minutely denticulated jaws described in this paper, or in the shales from which they were collected. On the other hand, certain of the Actinopterygii either do not possess laniaries or have them poorly developed, as for instance in the genera *Amblypterus* Agassiz and *Paleoniscus* Blainville. The teeth also differ in size, shape, and structure from the holoptychian type of dentition. For these reasons it is thought that these jaws are more closely related to the Actinopterygii. Traquair (2), however, has restricted *Amblypterus* to the Lower Permian and *Paleoniscus* to the Permian. Therefore, since no comparable Early Carboniferous forms have been described, it is proposed to erect a new family to include these peculiar fossils from the Lower Mississippian rocks of the United States.

Other fish remains found in the same black shale formations are occasional *Cladodus* and *Dinichthys* teeth and jaws, *Ctencanthus* spines, and scales of the ganoid type. The teeth here described are thought to be different from the dentition of any of these forms. No one of the specimens collected represents the entire length of the dentary. Assuming that the longest specimen is nearly whole, the dentary one-half the length of the head, and the head one-fourth to one-fifth the total length, then these fish were one foot, more or less, in length.

SYSTEMATIC DESCRIPTIONS

Order ACTINOPTERYGII
Sub-order CHONDROSTEI
Family ANGUSTIDONTIDAE Cooper, new family

Teeth long, slender, tapering, and disposed in a single row along maxilla and dentary. Laniaries absent. Pulp cavity present.

Genus ANGUSTIDONTUS Cooper, n. gen.

Dental plates long, narrow and thin. Teeth straight or very slightly curved, long, slender, gradually tapering to a sharp, needle-like point; usually several sizes, alternating in a regular manner.

Genotype: *Angustidontus seriatus.*

ANGUSTIDONTUS SERIATUS Cooper, n. sp.

Plate 12, figures 1–4, 7–10

Dental plate thin and narrow, carrying a single row of slender conical regularly tapering teeth of five different lengths arranged in regular order. This arrangement is similar to the 1-, ½-, ¼-, ⅛-, and 1/16-inch markings on a ruler and is characteristic of the genus. Pulp cavity present. Terminal cusp slightly curved toward the posterior end, and of the same length as the largest denticles.

Longest denticles average 2.15 mm. in length; shortest average 0.4 mm.; the others intermediate between these. Total length of dentary unknown.

ANGUSTIDONTUS GRACILIS Cooper, n. sp.

Plate 12, figures 5, 6, 11

Dental bar narrow, slender, carrying a single row of slender, conical, tapering denticles, the larger ones very slightly curved toward the posterior end. Teeth

of four different lengths as contrasted with *A. seriatus*, which has five. Length of longest denticles, average 2.05 mm.; shortest average 0.34 mm.

Types are deposited in Walker Museum, University of Chicago. The catalog numbers appear in the explanation of Plate 12.

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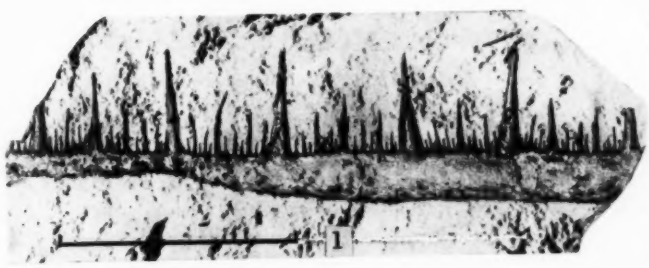
Explanation of Plate 12

(Lines represent a length of 5 mm.)

Figs. *1–4, 7–10—Angustidontus seriatus* Cooper, n. sp. *1*, Genoholotype, Walker Mus. (Univ. Chicago), 38096. *2*, Paratype, showing terminal cusp, but too poorly preserved to show the smallest denticles. Walker Mus. (Univ. Chicago), 38097. *3*, A crushed specimen showing the terminal cusp and several sizes of denticles. Walker Mus. (Univ. Chicago), 38098. Figures *1–3* from Woodford formation, sec. 21, T. 1 S., R. 8 E., near Clarita, Oklahoma. *4*, Specimen from inside a siliceous concretion; Linietta (Cuyahoga) clay, west of Junction City, Kentucky. Walker Mus. (Univ. Chicago), 38099. *7*, Specimen crushed, but showing clearly the denticles and terminal cusp; Woodford formation, sec. 2, T. 2 N., R. 6 E., Oklahoma. Walker Mus. (Univ. Chicago), 38102. *8*, A fragment from a siliceous concretion; top of Chattanooga shale, 1¼ miles east of Boston, Kentucky. Walker Mus. (Univ. Chicago), 38103. *9*, Part of a dentary with cast of pulp cavity preserved in a siliceous concretion; Woodford formation, Sycamore Creek, sec. 27, T. 3 S., R. 4 E., Oklahoma. Walker Mus. (Univ. Chicago), 38104. *10*, Horizon and locality same as figure *9*. Walker Mus. (Univ. Chicago), 38105. (p. 93)

5, 6, 11—Angustidontus gracilis Cooper, n. sp. *5*, Holotype; specimen flattened between layers of black shale; upper Cleveland shale, Chappel Creek, 1 mile southeast of Ashmont, Ohio. Walker Mus. (Univ. Chicago), 38100. *6*, Smallest denticles not shown owing to poor preservation; Sunbury shale, near Lithopolis, Ohio. Walker Mus. (Univ. Chicago), 38101. *11*, Terminal cusp much flattened; near top of Ohio shale, in quarry of Rowan County Freestone Co., Farmers, Kentucky. Walker Mus. (Univ. Chicago), 38106. (p. 93)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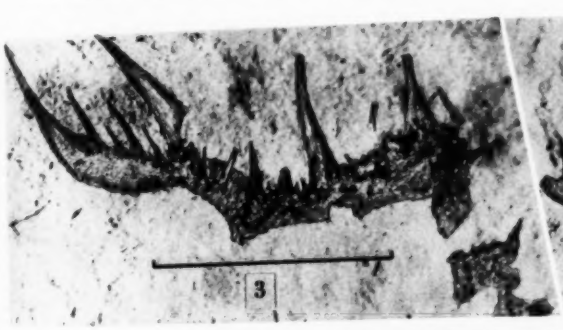
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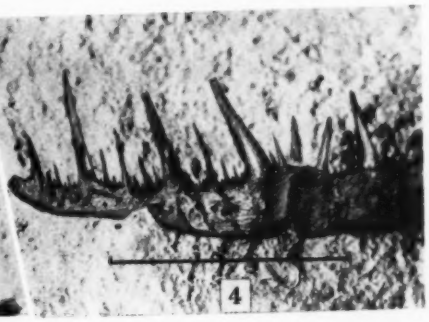
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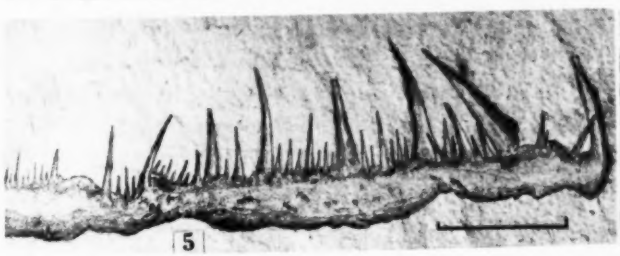
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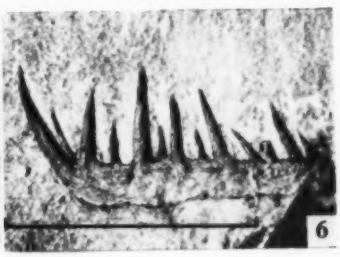
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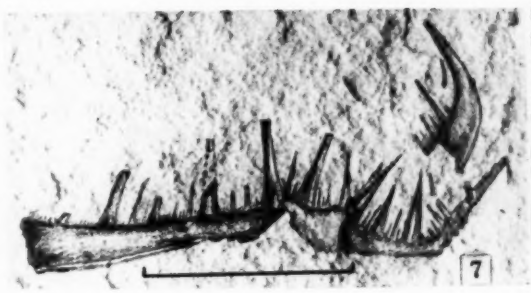
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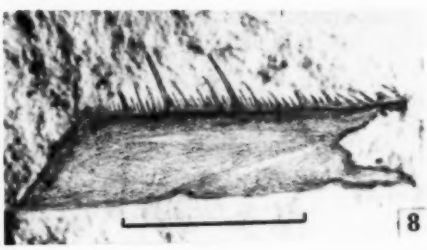
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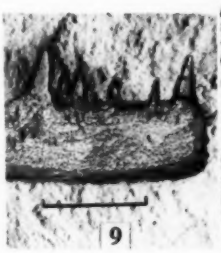
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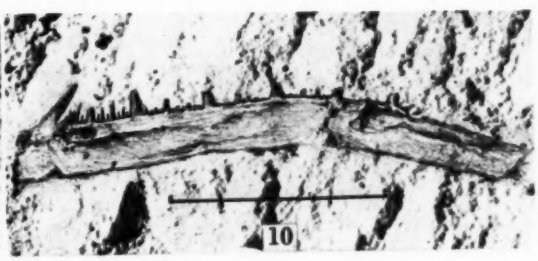
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Cooper, Mississippian Actinopterygian Jaws

JOURNAL OF PALEONTOLOGY, VOL. 10, NO. 2, PP. 95–113, PLS. 13–16, MARCH, 1936

FUSULINIDS FROM THE BLACK HILLS AND ADJACENT AREAS IN WYOMING

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ABSTRACT

Fourteen species and one variety of fusulinids from the Minnelusa formation of South Dakota and the Hartville formation of eastern Wyoming are described and illustrated. These include five new species and one new variety of *Fusulinella*, one previously described species of *Wedekindellina*, six species (two of which are new) of *Fusulina*, and two new species of *Triticites*. These Pennsylvanian fusulinids are compared with others from America, Europe, and Asia, and it is concluded that the fusulinids of the lower part of the Minnelusa are closely related to those of the lower part of the Hartville, and that the lower portions of both of these formations should be referred to the Morrow series. The fusulinid fauna of the middle part of Hartville is comparable to that of the mid-portion of the Cherokee shale (Des Moines series), and that of the upper part of the Hartville is Upper Pennsylvanian in age.

For a number of years the Carboniferous strata of the Black Hills and adjacent areas have been studied intermittently by various members of the Geology Department of the State University of Iowa, and several published and unpublished dissertations have dealt with these strata. Numerous collections were made during these studies and several of them contained fusulinids. These were placed at my disposal about four years ago when I began my work on fusulinids, and, in addition, during the summer of 1934 Mr. W. M. Furnish and I visited the localities from which these specimens came and obtained additional material. All of the specimens available were included in the study on which this report is based.

FAUNAL AND STRATIGRAPHIC COMPARISONS

The relative ages of the Pennsylvania strata of the Black Hills of South Dakota and of the eastern portion of Wyoming have been discussed by a number of workers, but their conclusions have varied markedly. In 1909 Darton (2) concluded that the upper portion of the Minnelusa formation of the southern Black Hills is Pennsylvanian in age but that the lower portion of this formation should probably be referred to the Mississippian. Also, in 1925 Darton and Paige (3) stated that the fauna of the upper portion of the Minnelusa near Hot Springs, South Dakota, is of Pennsylvanian age, and they concluded that the fauna from the basal red shales near Loring Siding, South Dakota, may be Mississippian in age. These authors also published what may be regarded as the first record of the occurrence of fusulinids in the Black Hills, for they state that Girty identified a form from the "medial" beds of the Minnelusa, northwest of Hermosa, South Dakota, as a "species of *Fusulina*."

In 1930 Dillé (4) published a list of fossils from the basal red shales of the Minnelusa near Loring Siding, and he concluded that these beds are of Lower Pennsylvanian (Des Moines) age. He listed as "*Fusulina* cf. *cylindrica*" a form which I am describing below as *Fusulinella dakotensis*, n. sp. In the same year Roth (8) published generalized sections of the Minnelusa of the Black Hills and of the Pennsylvanian strata in adjacent portions of Wyoming, and concluded that the Minnelusa should be correlated with the Cherokee, but that beds of Kansas City age were present in the North Platte River valley in eastern Wyoming.[1]

In the present report I am including descriptions of fusulinids from the lower 150 feet of the Minnelusa near Loring Siding, South Dakota (the total Minnelusa is about 500 feet thick at this locality); from the middle and upper portions of the Hartville formation in the canyon of the North Platte River about 8 miles southeast of Orin Junction, Wyoming, and from the lower 450 feet of the Hartville formation near Guernsey, Wyoming. The fusulinids from near Loring Siding belong to the primitive genus *Fusulinella*, and they are described below as *F. dakotensis*, n. sp., *F. furnishi*, n. sp., and *F. acuminata*, n. sp. Eight miles southeast of Orin Junction, *Fusulina rockymontana* Roth and Skinner? and *F. truncatulina*, n. sp., occur about 110 feet above the level of the river; *Fusulinella diminutiva*, n. sp., occurs about 150 feet above the level of the river; and *Triticites submucronata*, n. sp., and *T. milleri*, n. sp., occur about 280 and 350 feet, respectively, above the level of the river. At the Guernsey locality, *Fusulinella velmae*, n. sp., and *F. velmae protensa*, n. var., occur from 120 to 165 feet above the Mississippian limestone (Guernsey formation); *Fusulina distenta* Roth and Skinner, *F. euryteines* Thompson, and *Wedekindellina excentrica* (Roth and Skinner) occur about 350 feet above the Mississippian limestone; and *Fusulina plattensis*, n. sp., and *Fusulina* sp. occur about 450 feet above the Mississippian limestone.

Although the three species of the genus *Fusulinella* which occur in the lower portion of the Minnelusa of the Black Hills are not identical with the species and variety of this same genus which occur in the lower portion of the Hartville at Guernsey, they are closely related and these two horizons are apparently not greatly different in age.[2] In both of these localities the fusulinids are extremely abundant and occur throughout rather thick beds, but the absence of representatives of the genus *Fusulina* in both of these horizons is probably significant. The fusulinids which occur in these two

[1] Roth listed in his stratigraphic sections of this region numerous fusulinids which are undoubtedly conspecific with some of the species I am describing below. However, since he did not include descriptions or illustrations of his specimens, in some cases I am not able to tell just what forms he was studying, and therefore I did not include references to his work in all of my synonymies.

[2] In 1904 Darton (1) correlated these same beds, but on the basis of marine fossils from the lower portion of the Hartville at this same locality from which my specimens came, he referred them to the Mississippian.

horizons are closely related to *Fusulinella primaeva* (Skinner) (9) and *F. llanoensis* (Thomas) (11) of the Marble Falls limestone of Texas, *F. iowensis* Thompson of the basal portion of the Cherokee of Iowa (12), and *F. fittsi* Thompson and *F. prolifica* Thompson of the lower portion of the Atoka formation of Oklahoma (13); and the genus *Fusulina* has also not been recorded from these three horizons. All of the primitive fusulinid species listed above are closely related and they indicate that the beds from which they come are not greatly different in age. If the Marble Falls limestone is Morrow in age, as is now generally believed (7), it seems probable that all of these horizons of primitive fusulinids in Oklahoma, Iowa, Wyoming, and South Dakota should be included in the Morrow series. It should, perhaps, also be mentioned in this connection that the fusulinids under consideration are strikingly similar to primitive forms which Lee and Chen (6) have described from the Huanglung limestone of southern China.

My studies of the genus *Fusulina* from the Lower Pennsylvanian of America indicate that its specific representatives have very short vertical ranges but are widespread geographically; because of these facts and because specimens occur abundantly, representatives of *Fusulina* are very good index fossils. During the Lower Pennsylvanian there was a progressive development within the genus from the more primitive forms like *F. leei* Skinner to the more highly developed forms like *F. girtyi* (Dunbar and Condra), *F. mysticensis* Thompson, and *F. eximia* Thompson. The species listed last is the most highly developed representative of the genus known from America, and, with the possible exception of *F. quasicylindrica* (Lee) and *F. pankouensis* (Lee) of the Penchi series of north China, it is perhaps the most highly developed representative of the genus so far described. In so far as I have been able to determine, no representative of this genus (*Fusulina*) has ever been found in association with *Triticites*.

The fusulinid-bearing horizon about 350 feet above the Mississippian limestone near Guernsey, Wyoming, contains some species of fusulinids that are identical and some that are closely similar to the fusulinids known from the mid-portion of the Cherokee of Iowa, the Stonefort limestone of Illinois, and the upper part of the McCoy formation of Colorado. These forms indicate strongly that the fusulinid-bearing beds in these three widely separated localities are not greatly different in age. Also, the beds about 8 miles southeast of Orin Junction, Wyoming, which yielded *Fusulina truncatulina*, n. sp., may be very closely similar in age to the uppermost part of the Cherokee of Iowa, in which *F. lucasensis* occurs.

The beds about 8 miles southeast of Orin Junction, Wyoming, which yielded *Triticites submucronata* and *T. milleri*, are undoubtedly Upper Pennsylvanian in age. In 1930 Roth (8, p. 1263) correlated these beds in a general way with the Kansas City

group, but the fusulinids which I obtained from them seem to indicate that they more probably are upper Missouri or lower Virgil in age.

The genus *Fusulinella* is probably the ancestor of the genus *Triticites*, but transitional forms have not been found in America, at least. Representatives of *Triticites* were very abundant in the North American seas of the Missouri and Virgil epochs and that genus appears to have been much better developed on this continent than in other parts of the world. This pronounced development of *Triticites* in America has long been known, and it led Staff (10) to conclude that the genus had acquired its characteristics due to isolation and that the forms now generally referred to it should be regarded as aberrant members of the genus "*Fusulina*". Only a few representatives of *Triticites* have been described from Europe and Asia, and there they are generally found associated with the type of fusulinids which in America occur with *Triticites* in the Lower Permian.[3] Therefore, it seems probable that the pronounced development of this genus in America and its rarity elsewhere may be due to slight development of beds in Eurasia which are correlative with the American Upper Pennsylvanian. *Triticites* is represented in the Missouri and Virgil series of America by more than a score of species, and in these strata very few other fusulinids have been found. The very fossiliferous Upper Carboniferous and Permian strata (Penchi and Taiyuan series) of China have yielded some of our best known fusulinid faunas. The Penchi series (including the Huanglung limestone) of China is apparently equivalent to the American Morrow and Des Moines series, whereas essentially all of the Taiyuan series appears to be equivalent to the lower portion of the Permian of America. However, the extreme basal portion of the Taiyuan series, the Yaohou limestone of northwestern Kansu (Lee's Ps zone) (5), contains a meager *Triticites* fauna, and it is apparently equivalent to a small portion of the American Upper Pennsylvanian. It, therefore, seems that the hiatus between the Penchi series and the Taiyuan series of China may represent almost all of the Missouri and

[3] Since the manuscript of this report was completed I have received a copy of Chen's report on Fusulinidae of South China (*Palaeont. Sinica*, ser. B., vol. 4, fasc. 2, 1934) in which he describes twenty-five representatives of *Triticites*, and these forms are associated with Permian genera, such as *Schwagerina*.

EXPLANATION OF PLATE 13

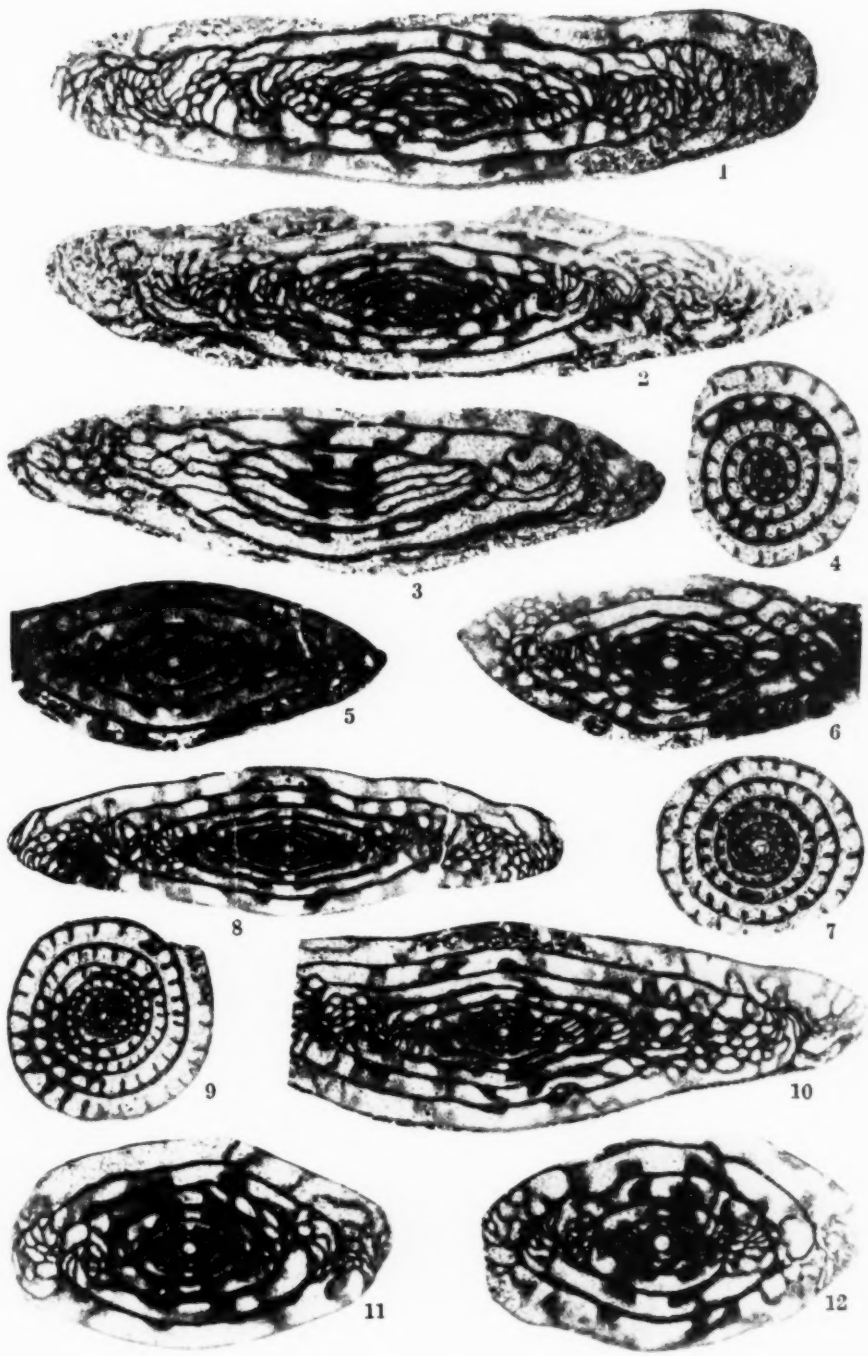
All illustrations on this plate are unretouched photographs and all are magnified ×20.

FIGS. *1–4—Fusulinella furnishi* Thompson, n. sp. *1*, Section tangential to the third volution; *2*, axial section; *3*, tangential section showing the nature of the septal fluting; *4*, sagittal section. From the Minnelusa formation of South Dakota. (p. 100)

5–7—Fusulinella acuminata Thompson, n. sp. *5*, *6*, Axial sections; *7*, sagittal section. From the Minnelusa formation of South Dakota. (p. 101)

8–10—Fusulinella dakotensis Thompson, n. sp. *8*, *10*, Axial sections; *9*, sagittal section. From the Minnelusa formation of South Dakota. (p. 99)

11, 12—Fusulinella velmae velmae Thompson, n. sp. and var. Axial sections. From the Hartville formation of Wyoming. (p. 101)



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Virgil series of America, and this would explain the scarcity of the genus *Triticites* in China. A few representatives of this genus have been reported from Europe, but it seems probable that the Upper Pennsylvanian is not as completely developed on that continent as it is in America.

SYSTEMATIC DESCRIPTIONS

Genus FUSULINELLA Möller

FUSULINELLA DAKOTENSIS Thompson, n. sp.

Plate 13, figures 8–10

Fusulina cf. *cylindrica* DILLÉ, *1930*, Am. Assoc. Petroleum Geologists, Bull., vol. 14, p. 620.

Shell small, elongate, slender, fusiform. Poles sharply pointed. External furrows shallow. Axis of coiling straight to slightly irregular. Mature forms of eight volutions are about 4.5 mm. in length and 1.4 mm. in width. The form ratio of mature individuals is about 1:3. The central portion of the shell is rather markedly inflated throughout growth and the lateral slopes are slightly concave.

The septa are thin. They are composed of five layers. However, all of these layers can be clearly seen only near the center of the shell in the outer volutions. The anterior diaphanotheca decreases in thickness very rapidly toward the base of the septa and in the lower portion of the septa it cannot be recognized. In the end portions of the shell the different layers of the septa cannot be differentiated. The septal count gives 16 to 17 for the third volution, 17 to 20 for the fourth volution, 17 to 22 for the fifth volution, 22 for the sixth volution, 25 to 27 for the seventh volution, and 27 for the eighth volution. The septa are rather broadly but highly fluted in the polar regions and they are essentially unfluted near the center of the shell.

The inside diameter of the proloculum is 55 to 63 microns. The average for a rather large number of specimens is about 60 microns. The inner three volutions are very tightly coiled. The heights of the chambers (including their overlying spirotheca) of the first eight volutions are 27, 35, 35, 62, 79, 97, 132, and 173 microns.

The spirotheca is thin. It is composed of four layers. Near the center of the tunnel of the seventh volution the upper tectorium may be absent in places and ranges up to 5 microns in thickness, the diaphanotheca is about 13 microns thick, and the lower tectorium is about 5 microns thick. The floor of the tunnel in most sections appears to be composed of the tectum of the spirotheca. Near the poles the different layers of the spirotheca are very difficult to differentiate, but the tectoria seem to increase in thickness poleward and the diaphanotheca becomes exceedingly thin.

The tunnel is very low and broad. In the sixth volution it is about one-sixth as high as broad and about one-third as high as the chambers. The tunnel angle measures 29° to 31° in the sixth volution and 29° to 33° in the seventh volution. The intersection of the tunnel with axial sections is irregular throughout all volutions, but it is much less irregular in the outer three or four volutions. The chomata are well developed. In the inner three or four volutions they are very asymmetrical and they extend almost to the poles. In the outer volutions they are less asymmetrical and are much narrower. In the seventh volution of forms of eight volutions the chomata are about two-thirds as high as the chambers, and there they are about one-third as high as wide.

Remarks.—*Fusulinella dakotensis* more closely resembles and presumably is more closely related to *F. furnishi*, n. sp., than any other known representative of this genus. These two species can be easily distinguished, for in *F. dakotensis* there

is a larger number of volutions, the proloculum is smaller, the septa are apparently less highly fluted, the rate of increase of the height of the chambers for the different volutions is much slower, the central portion of the shell is more highly inflated, and the tunnel angle is larger than in *F. furnishi*. *F. dakotensis* can be distinguished from *F. acuminata*, n. sp., by the fact that the proloculum of the species under consideration is smaller, its tunnel angle is smaller, its volutions are more tightly coiled, and its shell is longer.

Horizon and locality.—The shells of this species occur in a very thin limestone layer near the middle of a purple shale in the railroad cut, approximately one-half mile north of Loring Siding, South Dakota, and they make up a large part of a thin limestone bed in the red shale one mile north of Loring Siding (Pl. 13, figs. 8–10). The latter horizon is about 60 feet above the base of the Minnelusa formation and the former horizon is 90 to 100 feet above the base of the Minnelusa.

FUSULINELLA FURNISHI Thompson, n. sp.

Plate 13, figures 1–4

?*Fusulinella euthusepta*? ROTH, *1930*, Am. Assoc. Petrol. Geol., Bull., vol. 14, p. 1262.

Shell small and elongate, fusiform. Poles sharply to bluntly pointed. Lateral slopes low and convex. Mature specimens of six volutions are about 5 mm. in length and 1.3 to 1.4 mm. in width. The form ratio of mature individuals is 1:3.6 to 1:3.9—specimens with a form ratio nearer the larger ratio are the more common.

The septa are composed of five layers. However, the anterior diaphanotheca is very indistinct and it cannot be recognized in the lower two-thirds of the septa. Most of the septa are rather poorly preserved near the tunnel. The number of septa in the different volutions varies considerably with different specimens. The septal count for a typical specimen gives 8 for the first volution, 11 for the second and third volutions, 15 for the fourth volution, and 18 for the fifth and sixth volutions. The septa are highly and rather narrowly fluted in the regions of the poles. Near the center of the shell of the outer volution the septa are very weakly fluted in their lower one-fourth. The septa are apparently unfluted near the center of the shell of the inner volutions.

The proloculum is essentially spherical and its inside diameter measures from 60 to 80 microns—the average is about 75 microns. The rate of growth of the shell for successive volutions is rather uniform with different specimens. The heights of the chambers of the first six volutions of the figured sagittal section are 35, 61, 104, 140, 154, and 173 microns.

The spirotheca is of moderate thickness. It is clearly composed of four layers. The lower portion of the upper tectorium is not greatly different in density from the diaphanotheca. Near the center of the tunnel of the sixth volution the upper tectorium is 7 microns thick, the diaphanotheca is 8.7 microns thick, and the lower tectorium is 5.3 microns thick. The diaphanotheca thins rather rapidly poleward and it is not distinguishable in the regions of the poles.

The tunnel is very broad and low. Its intersection with axial sections is very irregular in all volutions. The chomata are very asymmetrical in the inner volutions but they become more nearly symmetrical in the outer volutions. In the fifth volution the chomata are about one-third as high as the chambers and about one-third as high as wide. The tunnel angle is 38° to 46° in the fifth and sixth volutions.

Remarks.—*Fusulinella furnishi* resembles rather closely *F. dakotensis*, described above, but the two species can be easily differentiated, for in *F. furnishi* the tunnel angle is larger, the rate of increase of the heights of the chambers is more rapid, there are fewer volutions, and the septa are apparently more highly

fluted than in *F. dakotensis*. The general shape of the shells of *F. furnishi* and *F. acuminata* are so different that further comparisons seem unnecessary. Externally this species resembles rather closely *Wedekindellina euthysepta* (Henbest) and it seems probable that the specimens from near Loring Siding which Roth referred to that species in 1930 actually represent this species.

This species is named in honor of Mr. W. M. Furnish, who assisted the writer in collecting part of the fusulinids on which this study is based.

Horizon and locality.—This species occurs in great abundance in a 3-foot ledge of light-gray limestone of the Minnelusa formation in the railroad cut approximately one-half mile south of Loring Siding, South Dakota. This horizon was given by Roth (8, p. 1262) as 100 feet above the base of the Minnelusa formation, but my measurements at this locality indicate that it is slightly more than 130 feet above the base of that formation.

FUSULINELLA ACUMINATA Thompson, n. sp.

Plate 13, figures 5–7

Shell small, rather short, uniformly fusiform. Poles sharply pointed. Mature forms of six volutions are about 3.6 mm. in length and 1.4 mm. in width, and they have a form ratio of 1:2.4 to 1:2.6. The profile of the shell remains very uniform throughout growth of the individual. The lateral slopes are very uniform and even.

The septa are rather numerous, but they increase in number very slowly from the second to the sixth volution. There are about 13 septa in the first volution, 17 in the second volution, 19 in the third volution, 20 in the fourth volution, 22 in the fifth volution, and 25 in the sixth volution. The septa appear to be only slightly fluted in the extreme polar regions.

The proloculum is essentially spherical and its inside diameter measures 95 to 130 microns. The rate of increase of the heights of the volutions is rather uniform. The heights of the chambers in the first five volutions are 34, 60, 78, 104, and 129 microns.

The spirotheca is relatively thin. The diaphanotheca is extremely thin in the first volution and it gradually increases in thickness to about 7 microns in the fourth volution, 8.8 in the fifth volution, and 12.2 in the sixth volution. In the fifth volution the upper and lower tectoria are each about 5 microns thick.

The tunnel is low and wide. In the fifth and sixth volutions it is about one-third as high as the chambers and about six times as wide as high. The tunnel angle is 36° to 43° in the fifth and sixth volutions. The chomata are well developed and are very asymmetrical. In the fourth and fifth volutions they are about one-half as high as the chambers and are over twice as wide as high.

Remarks.—*Fusulinella acuminata* is apparently very closely related to *F. dakotensis* and *F. furnishi;* however, the shape of its shell is so distinct from that of the last named species that further comparisons seem unnecessary. Its shell expands more rapidly than that of *F. dakotensis*, its proloculum is larger, its tunnel angle is typically larger, and it has a larger form ratio.

Horizon and locality.—This species occurs associated with *Fusulinella furnishi* in a 3-foot ledge of light-gray limestone of the Minnelusa formation in the railroad cut about one-half mile south of Loring Siding, South Dakota. This limestone is apparently 130 feet or more above the top of the Pahasapa limestone (Mississippian) on which the Minnelusa formation rests.

FUSULINELLA VELMAE var. VELMAE Thompson, n. sp. and var.

Plate 13, figures 11, 12; Plate 14, figures 5–7

Shell small, short, obese. The central portion of the shell is inflated. The lateral slopes are very steep and in some forms they are slightly concave. The poles are very bluntly rounded. Mature forms of six to six and one-half volutions are 2.6

to 2.8 mm. in length and 1.4 to 1.6 mm. in width. The form ratio is 1:1.7 to 1:2; however, the average is much nearer the larger ratio. The external furrows are shallow and they are essentially straight throughout the length of the shell.

The septa are relatively thick. They increase in number at a very uniform rate from the first to the sixth volution. There are 8 to 9 septa in the first volution, 12 to 14 in the second volution, 14 to 16 in the third volution, 17 to 19 in the fourth volution, 20 to 22 in the fifth volution, and 23 to 25 in the sixth volution. The structure of the septa is typical of the genus. In the lower portion of the septa the anterior diaphanotheca is very thin. The septa are weakly fluted in the extreme polar regions and they are essentially straight across the central portion of the shell.

The proloculum is small. It has an average inside diameter of about 70 microns. In a few specimens the proloculum has an inside diameter as large as 120 microns, while in others it has a diameter as small as 50 microns. The heights of the chambers in the first seven volutions are 43, 60, 87, 112, 164, 190, and 225 microns.

The structure of the spirotheca is clearly that of a typical representative of this genus. In many parts of some of the sections the spirotheca appears to be composed of only an upper tectorium and a tectum—the diaphanotheca and lower tectorium were apparently removed during fossilization. The diaphanotheca is invisible in the first volution, but it increases in thickness to 14 microns at the center of the tunnel of the fifth volution. At the same position the upper tectorium is 14 microns thick and the lower tectorium is 7 microns thick.

The tunnel is very low and broad. The chomata are well developed. In the inner three volutions they are very asymmetrical and extend from the tunnel to the poles, but in the outer volutions they become more nearly symmetrical. In the sixth volution the chomata are about one-half the height of the chambers. The tunnel angle is 42° to 48° in the sixth volution.

Remarks.—*Fusulinella velmae velmae* is closely similar and presumably very closely related to *F. primaeva* (Skinner) of the Marble Falls limestone of Texas. However, these two species are apparently specifically distinct for in the former species the shell has a different shape, the chomata are better developed, its inner volutions apparently are different, and its septa may be slightly more highly fluted. I have not studied repre-

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EXPLANATION OF PLATE 14

All illustrations on this plate are unretouched photographs.

FIGS. *1–4*—*Fusulinella velmae* var. *protensa* Thompson, n. var. *1*, *3*, Axial sections, ×20; *2*, sagittal section, ×20; *4*, external view, ×10. From the Hartville formation of Wyoming. (p. 103)

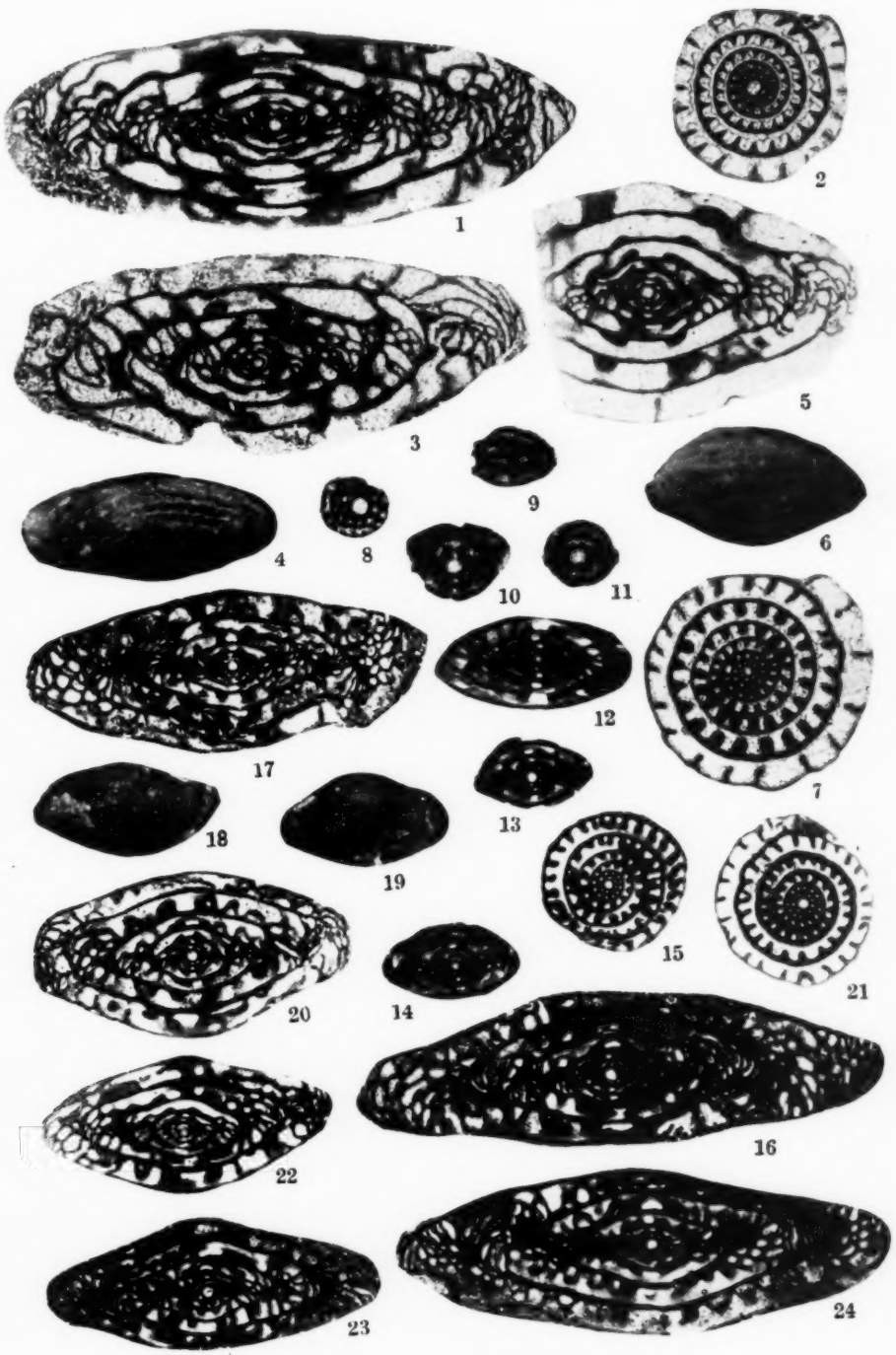
5–7—*Fusulinella velmae* var. *velmae* Thompson n. sp. and var. *5*, Axial section, ×20; *6*, external view, ×10; *7*, sagittal section, ×20. From the Hartville formation of Wyoming. (p. 101)

8–11—*Fusulinella diminutiva* Thompson, n. sp. *8*, Sagittal section, ×40; *9*, tangential section showing the unfluted septa, ×40; *10*, *11*, axial sections, ×40. From the Hartville formation of Wyoming. (p. 104)

12–17—*Fusulina plattensis* Thompson, n. sp. *12*, *14*, *16*, *17*, Axial sections of mature and juvenile specimens, ×20; *13*, axial section of the inner three volutions of a mature form of seven volutions, ×20; *15*, sagittal section, ×20. From the Hartville formation of Wyoming. (p. 109)

18–22—*Fusulina truncatulina* Thompson n. sp. *18*, *19*, External views ×10; *20*, *22*, axial sections, ×20; *21*, sagittal section, ×20. From the Hartville formation of Wyoming. (p. 108)

23, *24*—*Fusulina* sp. Axial sections, ×20. From the Hartville formation of Wyoming. (p. 111)



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sentatives of this Texas species or of *F. llanoensis* (Thomas) from the same formation and general locality in Texas, and it is probable that other differences can be pointed out when direct comparisons are made.

Some of the main differences which can be pointed out at the present time between *F. velmae* and *F. llanoensis* are that the tunnel angle of the former is larger, the septa are not so highly fluted, and the shell has a different shape.

Horizon and locality.—The syntypes of this species came from the west bluff of North Platte River, 100 yards west of the power house of the dam north of Guernsey, Wyoming. The lowest occurrence is in a lavender-colored shale immediately below a 5-foot bed of limestone, a few feet above the level of the top of the power house; and they occur again very abundantly in the shales and limestones between 50 and 65 feet above the level of the roof of the power house (Pl. 13, figs. 11, 12; Pl. 14, figs. 5–7).

FUSULINELLA VELMAE var. PROTENSA Thompson, n. var.

Plate 14, figures 1–4

Shell small, elongate and uniformly fusiform. Poles bluntly rounded. External furrows shallow and essentially straight throughout the length of the shell. Mature specimens of six volutions are 3.6 to 4 mm. in length and 1.4 mm. in width. The form ratio is about 1:2.9. The lateral slopes are low and convex in most specimens; however, a few specimens have rather sharply pointed poles, slightly inflated central portions, and form ratios of less than 1:3.

The septa are relatively thick. They increase in number somewhat uniformly from the first to the fifth volution. In four typical specimens there are 10 septa in the first volution, 14 in the second volution, 16 to 18 in the third volution, 18 to 21 in the fourth volution, and 21 in the fifth volution. The septa are rather closely fluted in the extreme polar regions, but they are essentially unfluted in the central one-half of the shell. The septa are clearly composed of five layers. However, the anterior diaphanotheca becomes very thin near the base of the septa and the posterior diaphanotheca appears to extend onto the tectum of the preceding volution of some sections.

The spirotheca is thin. It is composed of four layers, but in most parts of the specimens sectioned the lower tectorium has been destroyed and in many specimens the diaphanotheca has not been preserved. Near the center of the tunnel of the fifth volution of a typical specimen, the diaphanotheca is 12 microns thick and the upper tectorium is about 15 microns thick.

The proloculum is essentially spherical and its inside diameter measures 70 to 100 microns. The rate of expansion of the shell is very uniform. The heights of the chambers of the first six volutions measure 52, 60, 87, 112, 156, and 182 microns.

The tunnel is low and very broad. In the sixth volution the tunnel is about one-half as high as the chambers and about one-seventh as high as wide. The tunnel angle is about 47° in the sixth volution. The chomata are asymmetrical. In the fifth volution they are about two-thirds the height of the chambers and about four times as broad as high.

Remarks.—This variety is very similar to the variety *F. velmae velmae* in all respects except the shape of the shell and the development of the chomata. In the variety *protensa* the shell of mature individuals is 3.6 to 4 mm. in length compared to 2.6 to 2.8 for mature forms of the variety *velmae*. Also the chomata of the variety *protensa* are more asymmetrical, lower, and broader.

This species is known to range through about 65 feet of beds, but the variety *protensa* has been found in only the upper 15 feet of these beds. In this upper 15 feet there are three layers of light-gray limestone which are filled with the shells of *F. velmae velmae* and *F. velmae protensa*. The fusulinids in the lower of these

layers are almost all referable to variety *velmae* whereas the fusulinids of the upper limestone are almost all referable to the variety *protensa*. All gradations between these two varieties have been found and the evolution seems to have been from the short to the long variety.

The general shape of *F. velmae protensa* is closely similar to that of *F. prolifica* Thompson of the Atoka formation of Oklahoma. However, the Oklahoma form is much smaller, has quite different chomata, and has a smaller proloculum and thinner spirotheca. *F. velmae protensa* also resembles *F. primaeva* (Skinner) and *F. llanoensis* (Thomas) of the Marble Falls limestone of Texas, but in *F. llanoensis* the tunnel angle is smaller, the septa are more narrowly fluted, the chomata have a different structure, and the shapes of the shells are different. The shell of *F. primaeva* is shorter than that of the species under consideration and its chomata are different.

Horizon and locality.—The syntypes of this variety came from 15 feet of shale and limestone beds about 50 to 65 feet above the level of the top of the power house at the dam on North Platte River, near Guernsey, Wyoming.

FUSULINELLA DIMINUTIVA Thompson, n. sp.

Plate 14, figures 8–11

Shell very minute, short, and ellipsoidal. The poles are rounded and the lateral slopes are low, giving rise to an elliptical profile. Mature forms consist of two and one-half to three volutions and they are about 0.35 mm. in length and about 0.28 mm. in width. The form ratio is about 1:1.3 for mature individuals. The inner one or two volutions are subglobular in shape, and the first volution is subumbilicate.

The septa are thin and numerous. A typical specimen has 10 septa in the first volution and 15 in the second volution. They are apparently unfluted throughout the length of the shell, except possibly in the extreme polar regions.

The extreme thinness and the nature of preservation of the spirotheca makes impossible a determination of its exact structure. However, it is apparently coated on both sides with a layer of tectorium. There is no good reason to believe that the spirotheca of this species has a structure different from that of other representatives of this genus.

The proloculum is extremely small and its inside diameter measures only about 25 microns. The rate of expansion of the shell is very uniform.

The tunnel is almost circular in cross section. The chomata are well developed and they are very asymmetrical. Their slopes on the tunnel-side are very steep but their poleward slopes are very low. The chomata extend essentially to the poles.

Remarks.—*Fusulinella diminutiva* is the smallest species of fusulinids known from America. It belongs to the group of species that have been referred to the genus *Schubertella* Staff and Wedekind and it is comparable in size to the type of that genus, *Fusulinella transitoria* (Staff and Wedekind). Lee and Chen (6) have described some closely similar species from China and at least two

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EXPLANATION OF PLATE 15

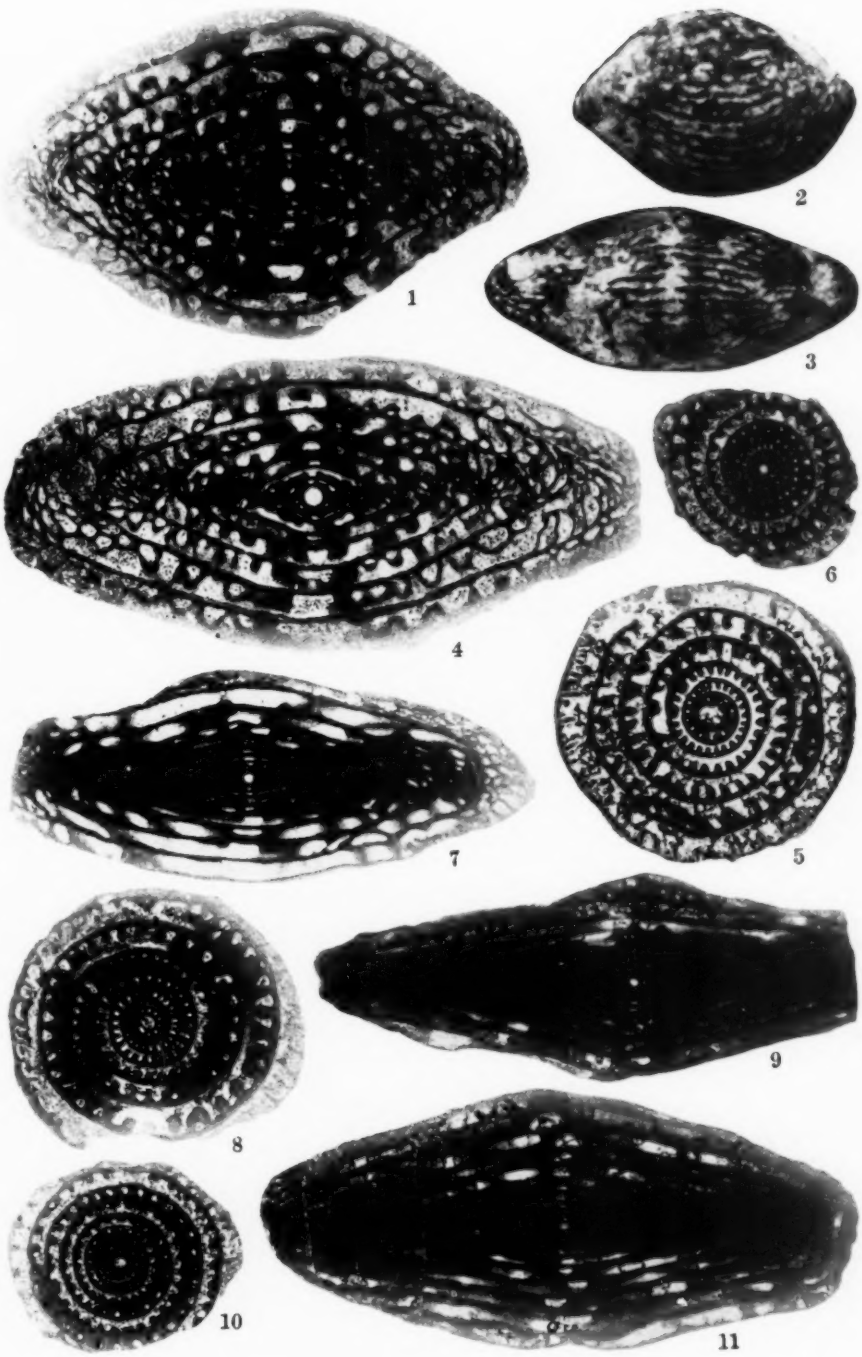
All illustrations on this plate are unretouched photographs and all are magnified ×20, except figures *2* and *3* which are magnified ×10.

FIGS. *1, 2, 8*—*Fusulina distenta* Roth and Skinner. *1*, Axial section; *2*, external view; *8*, sagittal section. From the Hartville formation of Wyoming. (p. 106)

3–5—*Fusulina euryteines* Thompson. *3*, External view; *4*, axial section; *5*, sagittal section. From the Hartville formation of Wyoming. (p. 107)

6, 9–11—*Wedekindellina excentrica* (Roth and Skinner). *6*, Sagittal section; *9, 11*, axial sections; *10*, sagittal section. From the Hartville formation of Wyoming. (p. 105)

7—*Wedekindellina coloradoensis perforata* Roth and Skinner. Axial section of a topotype from the lower fossiliferous horizon of the McCoy formation at McCoy, Colorado. (p. 105)



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closely similar forms are known from America, *Fusulinella gallowayi* (Skinner) and *F. oliviformis* Thompson. However, the two American species just mentioned are much larger and have a thicker spirotheca than has *F. diminutiva*. In 1932 White (14) described a form from the Graham formation of Texas as "*Triticites* sp. B" which resembles this group of species, but White has stated that the spirotheca of his specimens has a typical "triticitian" structure. This is the only fusulinid that White has listed from the locality and horizon at which he obtained his specimens of this form, but he states that they represent young individuals.

Horizon and locality.—The syntypes of this species came from a 6-foot, very arenaceous, light-gray limestone, about 150 feet above the level of the river, on the west bluff, near the north end of the canyon of North Platte River, sec. 8, T. 30 N., R. 68 W., about 8 miles southeast of Orin Junction, Wyoming.

Genus WEDEKINDELLINA Dunbar and Henbest

WEDEKINDELLINA EXCENTRICA (Roth and Skinner)

Plate 15, figures 6, 9–11; Plate 16, figure 12

Wedekindella excentrica ROTH AND SKINNER, *1930*, Jour. Paleontology, vol. 4, pp. 340, 341, pl. 30, figs. 1–3.

This species was recently described and illustrated in this Journal by Roth and Skinner and there is no need to duplicate their work. However, I am illustrating some of my Wyoming specimens and a topotype of *W. coloradoensis perforata* (Roth and Skinner) from the lower fossiliferous horizon at McCoy, Colorado, for comparison.

There are two groups of specimens in my Wyoming collection which may represent distinct varieties, but I am tentatively referring them to the same species. The major difference between these two groups is to be found in their form ratios. In one of these groups of specimens, mature forms are about 5 mm. in length and 1.6 mm. in width and have a form ratio of about 1:3.1. In the other group, mature forms are about 4 mm. in length and 1.8 mm. in width and have a form ratio of about 1:2.2. The first of these groups is represented by figures 6 and 9 on plate 15 and figure 12 on plate 16, and the second group is represented by figures 10 and 11 on plate 15.

The longer type of specimens just mentioned seems to be referable to the species *excentrica*, but the general shape of the shell of the second group agrees more closely with that of Roth and Skinner's *W. magna*. However, I am tentatively regarding them as the same variety. There are 10 to 11 volutions in mature representatives of both groups, and the inside diameter of the proloculum of each measures 60 to 70 microns. The tunnel angle of both groups is about 21° in the ninth volution. The tectum is easily distinguishable in the septa and the spirotheca, and the diaphanotheca of the spirotheca increases in thickness from a very thin layer in the inner volution to about 17.5 microns in the eighth volution. The septal count of both groups agrees very closely with that given by Roth and Skinner for the variety *excentrica*

Remarks.—*W. excentrica* is easily distinguished from *W. coloradoensis coloradoensis* (Roth and Skinner) and *W. coloradoensis perforata* (Roth and Skinner), for in the latter two forms the tunnel angle is larger and the fillings in the axial regions are not as heavy—in some specimens of *W. coloradoensis perforata* the tunnel angle is as large as 35°. *W. excentrica* can be distinguished from *W. henbesti* (Skinner) by its smaller tunnel angle (Skinner gives the tunnel angle of *W. henbesti* as 27° to 29°) and larger form ratio, and the axial filling of the former species seems to be much heavier. *W. excentrica* and *W. euthysepta* (Henbest) are very closely similar and it may not be possible to distinguish them specifically. However, it now appears that *W. euthysepta* has a much smaller

proloculum, has a smaller form ratio, and is smaller in size.

Nine species and two varieties have been recognized that are referable to *Wedekindellina*. With the exception of *W. rawi* (Lee) of the Lower Pennsylvanian of Manchuria, all of these species and varieties are known only from America.[4] All of the American representatives occur at approximately the same horizon and only in the central portion of the continent. The Manchurian species is found associated with representatives of the genus *Fusulina* s. s. which are apparently very closely related to the representatives of *Fusulina* found associated with representatives of *Wedekindellina* in America. The vertical range of the genus *Wedekindellina* appears to be shorter than that of any other of the prolific genera of fusulinids. That ten species or varieties of one genus existed almost simultaneously over such a small area in America seems open to question. Furthermore, the value of the characters by which species and varieties of this genus are differentiated is open to question. However, rapid evolutionary developments which may have caused the early extermination of this peculiar group of fusulinids may well have given rise in a short period of time to a large number of distinct forms.

Horizon and locality.—The specimens on which this study is based came from approximately 200 feet above the level of the lake, about three-fourths of a mile west of the dam on North Platte River, near Guernsey, Wyoming (Pl. 15, figs. 6, 9–11; Pl. 16, fig. 12). The syntypes came from the McCoy formation near McCoy, Colorado.

Genus FUSULINA Fischer de Waldheim

FUSULINA DISTENTA Roth and Skinner

Plate 15, figures, 1, 2, 8

Fusulina distenta ROTH and SKINNER, *1930*, Jour. Paleontology, vol. 4, pp. 346, 347, pl. 31, figs. 1–3.

This species was recently described by Roth and Skinner in this Journal and there is no need for me to duplicate their work. However, these authors illustrated polished sections of their types and, since the internal structures of fusulinids can best be understood from illustrations of thin sections, I am figuring some of the Wyoming specimens.

The diaphanotheca of the spirotheca increases in thickness from an almost invisible layer in the first volution to about 18 microns in the seventh volution. The lower portion of the upper tectorium of the spirotheca is very similar in density to the diaphanotheca on the opposite side of the tectum; but the anterior diaphanotheca of the septa is very thin. The other data from my specimens agree very closely with those given by Roth and Skinner.

As pointed out by Roth and Skinner, this species resembles rather closely *F. girtyi* (Dunbar and Condra) in size and shape. However, in *F. distenta* the chomata are much better developed, the tunnel angle is larger, and the septa are not so highly or narrowly fluted. This species under consideration is apparently rather closely related to *F. pumila* Thompson of the Des Moines series of Iowa, but *F. pumila* is smaller, contains fewer volutions, and the diaphanotheca is thinner for corresponding volutions. *F. distenta* is rather closely similar to *F. euryteines* Thompson, but it can be distinguished from that species for it has a larger form ratio, a smaller tunnel angle, more highly developed chomata, and usually a smaller proloculum. One of the last two species just mentioned is short and the other is long and they are found associated in the same bed of limestone. Somewhat similar association of a short and a long closely similar "species" of fusulinids is rather common. In the Des Moines series of Iowa the

[4] Recently Doutkevitch (*Petroleum Prosp. Geol. Inst.*, A, vol. 36, pp. 1–98, 1934) and Semichatov (*Geol. Mag.*, vol. 72, pp. 433–441, 1935) reported very abundant *Wedekindellina* faunas from the Lower Pennsylvanian of Russia.

following species of this same genus occur together: *F. euryteines* and *F. pumila*, *F. girtyi* and *F. stookeyi* Thompson, and *F. mysticensis* Thompson and *F. megista* Thompson. Also the association of a short and a long closely similar species of other genera, such as *Triticites* and *Fusulinella*, has been recorded a number of times. In all of the cases cited above from the Des Moines series of Iowa and in other associated long and short species of fusulinids with which I am familiar, there are characters which are generally regarded as being of specific value, other than the shapes of the shells, by which these associated forms may be distinguished. Nevertheless, there is a possibility that those two types of specimens so commonly associated are sexual or dimorphic representatives of the same species. However, since we are now able to recognize and separate these two types of forms, and further since so many long as well as short species of fusulinids occur alone, it would seem to me best, for the present at least, to continue to designate them by different names.

Horizon and locality.—The specimens on which this study was made came from the shale immediately below a 3-foot ledge of limestone on the bluff about 200 feet above the lake, three-fourths of a mile west of the dam on North Platte River near Guernsey, Wyoming (Pl. 15, figs. 1, 2, 8). This limestone is about 350 feet above the Mississippian limestone. The syntypes came from the McCoy formation near McCoy, Colorado.

FUSULINA EURYTEINES Thompson

Plate 15, figures 3–5

Fusulinella meeki DUNBAR AND CONDRA, *1927*, Nebraska Geol. Survey, Bull. 2, pp. 78–80, pl. 15, figs. 4–6, and (?) pl. 2, figs. 12–14. [Not *Fusulina ventricosa meeki* Möller, 1879.]—WARTHIN, *1930*, Oklahoma Geol. Survey, Bull. 53, pp. 32, 33, pl. 2, fig. 11.

Fusulinella, n. sp. HENBEST, *1928*, Jour. Paleontology, vol. 2, p. 79, pl. 10, figs. 2, 4.

?*Fusulina meeki* WHITE, *1932*, Univ. Texas, Bull. 3211, pp. 27–30, pl. 1, figs. 7–12.

Fusulina euryteines THOMPSON, *1934*, Univ. Iowa, Studies Nat. Hist., vol. 16, pp. 310–313, pl. 22, figs. 4, 13, 14, 18.

The specimens from Wyoming which I am referring to this species differ somewhat from the syntypes, which came from the Cherokee of Iowa, but the differences do not seem to me to be of specific value. Nevertheless, for the sake of comparison, I am describing and illustrating the Wyoming specimens.

Shell small, fusiform. Poles bluntly pointed. Lateral slopes convex and rather low. In young individuals the poles are sharply pointed but during no stage of development is there a tendency toward inflation of the central portion of the shell. Mature individuals consist of seven to eight volutions, are about 5.4 mm. in length and 2.1 mm. in width, and have a form ratio of about 1:2.6.

The septa are very numerous. The septal count of the first to the sixth volution of a typical specimen is 13, 26, 27, 32, 40, and 40. The septa are clearly composed of five layers, but the anterior diaphanotheca is very thin. The septa are fluted, though somewhat moderately so, throughout the length of the shell, and the fluting extends essentially to the top of the septa. The proloculum has an inside diameter of about 140 microns.

The spirotheca are only moderately thick for the genus. Near the center of the tunnel of the fifth volution, the upper tectorium is 14 microns thick, the diaphanotheca is 12 microns thick, and the lower tectorium is 18 microns thick. Near the center of the shell, the diaphanotheca of the sixth volution is about 18 microns thick. Poleward the tectoria decrease in thickness, and near the poles the upper tectorium is only about 4 microns thick and the lower tectorium is about 1 micron thick.

The tunnel is rather low and narrow. In the seventh volution it is about one-half the height of the chambers and about one-third as high as wide. The intersection of the tunnel with axial sections forms a somewhat irregular course in the inner four volutions but in

the outer volutions the course becomes more regular. The chomata are well developed throughout the shell, except in the latter part of the outer one volution. They are narrow and asymmetrical, and are about three-fourths as high as the chambers in the fifth and sixth volutions. The tunnel angle is about 23° in the fifth and sixth volutions, and it is about 29° in the eighth volution.

Remarks.—The Wyoming specimens on which this study is based have a more nearly symmetrical shell than do most of the syntypes, the lateral slopes are not concave as in many of the syntypes, and the central portion is not inflated as in the syntypes. Also, the Wyoming specimens are slightly larger and longer than the Iowa specimens. Nevertheless, both the Iowa and the Wyoming forms are closely similar, are of approximately the same age, and occupy about the same position in the evolutionary series of the genus; and it therefore seems to me that, at least until further data are obtained, they should be considered as representing only one species.

Horizon and locality.—The specimens on which the above description is based came from the shale immediately below a 3-foot ledge of light-gray limestone on the bluff about three-fourths of a mile west of the dam on North Platte River near Guernsey, Wyoming (Pl. 15, figs. 3–5). This horizon is about 200 feet above the level of the lake and about 350 feet above the Mississippian limestone. The syntypes came from the middle portion of the Cherokee of Iowa and conspecific forms have been reported by Dunbar and Condra from over the Rich Hill coal near Rich Hill, Missouri; by Henbest from the Stonefort limestone of southern Illinois; by Warthin from the upper portion of the Wetumka formation of Oklahoma; and some forms have been described and illustrated by Dunbar and Condra and by White from the Millsap formation of Texas that may be conspecific.

FUSULINA TRUNCATULINA Thompson, n. sp.
Plate 14, figures 18–22

Shell small, short, fusiform. Poles bluntly pointed. External furrows shallow. Mature forms of six volutions are about 2 mm. in length and 1 to 1.2 mm. in width. The form ratio is 1:2 to 1:1.6. The central portion of mature shells is inflated and the lateral slopes become slightly concave in some specimens; however, in very short specimens the lateral slopes are very steep and the poles are rounded.

The proloculum is small. Its inside diameter measures 50 to 85 microns; the average for six specimens being 70 microns. The expansion of the volutions is rather gradual, and the heights of the first six volutions are 43, 61, 70, 96, 156, and 173 microns.

The spirotheca is relatively thick for the genus. The diaphanotheca increases in thickness from an almost invisible layer in the first volution to about 20 microns in the fifth volution. The tectoria are well developed and they change in thickness only slightly from the center of the shell to the poles—near the center of the shell of the fifth volution they each measure about 9 microns in thickness.

The septa are thick, they are rather numerous, and they have a structure typical of the genus. In a typical specimen there are 10 septa in the first volution, 14 in the second volution, 16 in the third volution, 21 in the fourth volution, and 25 in the fifth volution. In the inner three or four volutions the septa are broadly fluted in the polar regions, but they are essentially unfluted near the tunnel. In the outer volutions the septa are fluted throughout the length of the shell, but they are not brought in contact by the fluting near the center of the shell.

The tunnel is rather high and narrow from the first to the fifth volution, and in the sixth volution it becomes rather wide. The tunnel angle is about 25° in the fifth volution, but it is as large as 46° in the sixth volution. The chomata

are well developed. In the inner three volutions they are very asymmetrical and extend almost to the poles. In the outer volutions they become more nearly symmetrical and are over one-half the height of the chambers in the fifth and sixth volutions.

Remarks.—The internal structures of this species are somewhat similar to those of the very small species, *Fusulina lucasensis* Thompson, of the upper portion of the Cherokee of Iowa, and the two species seem to have reached a similar stage of development. *F. truncatulina* is also somewhat similar to *F. plattensis*, described below, but its shell is smaller and shorter, its septa are more highly fluted, and its shell expands more rapidly.

Horizon and locality.—The syntypes came from a 6-foot bed of medium-gray limestone, about 110 feet above the level of the river, on the west bluff, near the north end of the canyon of North Platte River, in sec. 8, T. 30 N., R. 68 W., about 8 miles southeast of Orin Junction, Wyoming.

FUSULINA ROCKYMONTANA Roth and Skinner?

Plate 16, figures 10, 11

Fusulina rockymontana ROTH AND SKINNER, *1930*, Jour. Paleontology, vol. 4, pp. 344, 345, pl. 31, figs. 4–6.

Among my Wyoming collections there are a few sections of a rather large representative of this genus which agree closely with the description and illustrations of the syntypes of this species, but which may not be conspecific with them. A closer specific determination is not possible from the few specimens in my collection from Wyoming and hence I am tentatively referring them to this species. *F. rockymontana* was recently described and illustrated in this Journal by Roth and Skinner but since their illustrations are of polished sections, and not of thin sections as is common practice today, I am figuring thin-sections of a topotype from the lower fossiliferous horizon at McCoy, Colorado (Pl. 16, fig. 1), and of two of my specimens from Wyoming.

The Wyoming specimens of seven volutions measure about 4.5 mm. in length and 1.9 mm. in width, whereas one of my topotypes of six and one-half volutions is about 4.5 mm. in length and 1.9 mm. in width. The inside diameter of the proloculum of one of the Wyoming specimens is about 100 microns, and the tunnel angle of the same specimen is 38° in the seventh volution. The tunnel angle for the same volution of one of my topotypes is also 38°. The diaphanotheca of one of the topotypes is 8.7 microns in the third volution, 10.5 microns in the fourth volution, 12.2 microns in the fifth volution, and 15.7 microns in the sixth volution, but the thickness of the diaphanotheca of the six volution of the Wyoming specimens is about 18 microns. In the Wyoming specimens the chomata are not uniform and the septa are apparently slightly more narrowly fluted.

Fusulina rockymontana is similar in general shape to *F. euryteines* but the internal structures of the two species are quite different. In the former species the chomata are more uniform throughout the shell and more nearly like those of the genus *Fusulinella*, the septa are not as highly or narrowly fluted, and the tunnel angle is much larger.

Horizon and locality.—The syntypes of this species came from the McCoy formation near McCoy, Colorado, and the specimens from Wyoming which I am referring with question to this species came from a 6-foot bed of pale purplish-gray limestone, about 110 feet above the level of the river, near the north end of the canyon of Noth Platte River, in sec. 8, T. 30 N., R. 68 W., about 8 miles southeast of Orin Junction, Wyoming (Pl. 16, figures 10, 11).

FUSULINA PLATTENSIS Thompson, n. sp.

Plate 14, figures 12–17

Shell small, elongate fusiform; with sharply pointed poles and low lateral

slopes. Mature forms consist of six to seven volutions and are about 3.5 mm. in length and 1.5 mm. in width. The form ratio of mature forms is about 1:2.3. The inner two or three volutions are short, they have an elliptical profile, their poles are very bluntly pointed, their septa are fluted only in the extreme polar regions, and their chomata are very asymmetrical and well developed. In at least the outer three volutions the poles become more sharply pointed, the chomata are more nearly symmetrical, and the septa are apparently fluted throughout the length of the shell; however, in these volutions the fluting seems to be very broad and weak near the center of the shell and the septa apparently are not brought in contact by the fluting.

The inside diameter of the proloculum measures 60 to 70 microns. The inner two volutions are very tightly coiled and the outer volutions are more rapidly expanding. The heights of the first six volutions are 35, 43, 70, 138, 173, and 216 microns.

The diaphanotheca of the spirotheca is rather thick for the genus, but the tectoria are exceptionally thin in the outer three volutions. Near the center of the shell of the seventh volution, the diaphanotheca is about 30 microns thick. At the same position of the sixth volution, the upper tectorium is about 5 microns thick, the diaphanotheca is about 20 microns thick, and the lower tectorium is about 9 microns thick. In the fourth volution the diaphanotheca is only about 10 microns thick. In the outer three volutions the tectoria thin rapidly poleward and they are very thin or absent in the polar regions.

The septa are rather numerous. The septal count of a typical specimen gives 8 for the first volution, 13 for the second and third volutions, 18 for the fourth volution, and 25 for the fifth volution.

The tunnel is very narrow and its course is slightly irregular in the inner three volutions, but in the outer volutions its course becomes more nearly straight, and there it is low and wide. In the sixth volution the tunnel angle is about 33°. The chomata are well developed in all volutions except the last half of the outer one. In the fifth and sixth volutions they are essentially symmetrical and are about one-half as high as the chambers. The chomata of the inner three volutions extend essentially to the poles.

Remarks.—The inner volutions of this species are like those of typical *Fusulinella* and the outer volutions are like those of typical *Fusulina*. However, even in the outer volutions the septa are not as highly fluted as are those of some earlier representatives of the genus *Fusulina*. The weakly fluted septa, thick diaphanotheca in the outer volutions, and the thin tectoria suggest that perhaps this form is closely related to the genus *Triticites* and has developed di-

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EXPLANATION OF PLATE 16

All illustrations on this plate are unretouched photographs and all are magnified ×20.

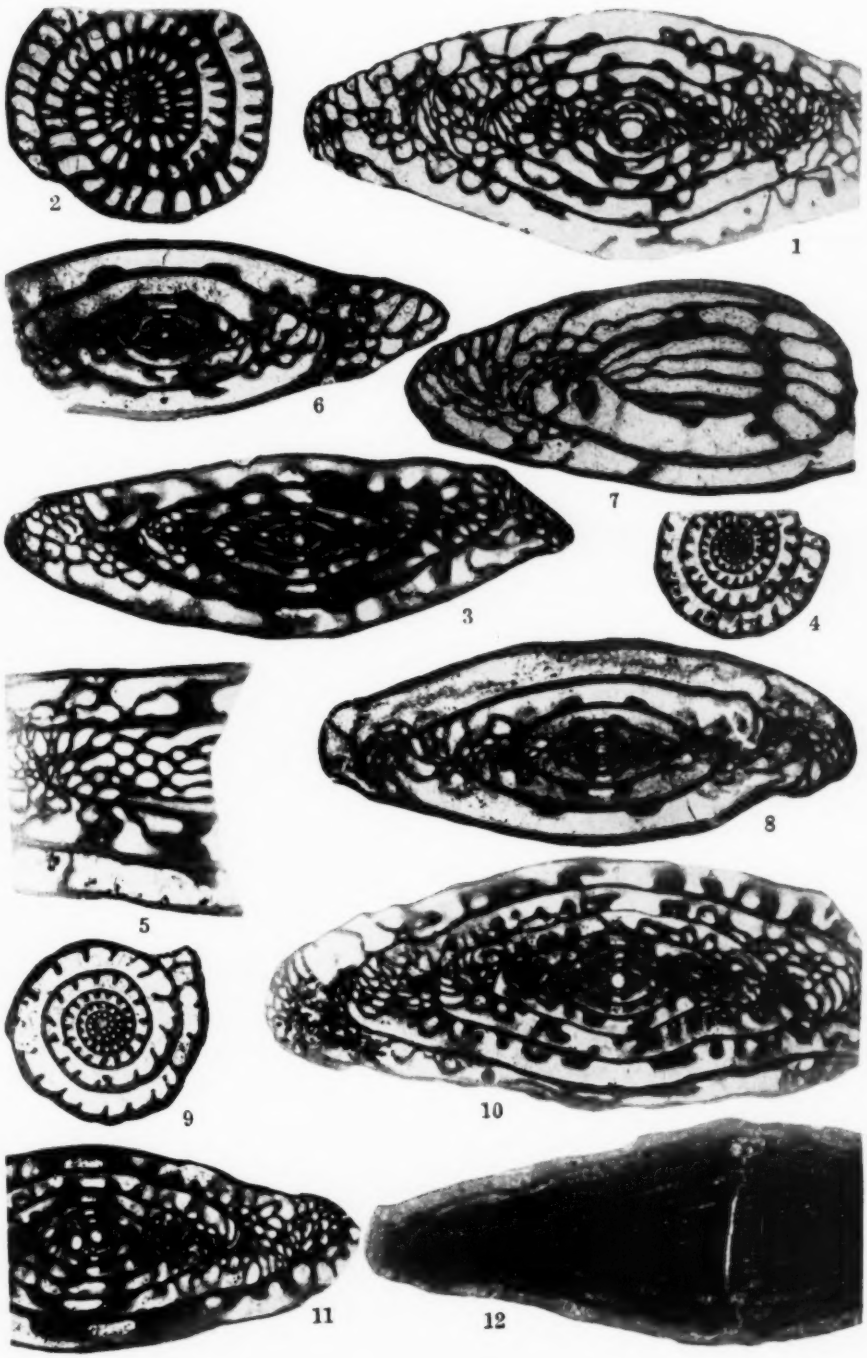
FIGS. *1*—*Fusulina rockymontana* Roth and Skinner. Axial section of a topotype from the lower fossiliferous horizon of the McCoy formation at McCoy, Colorado. (p. 109)

2–5—*Triticites submucronata* Thompson, n. sp. *2*, Excentric section; *3*, axial section; *4*, sagittal section; *5*, a portion of a tangential section showing the nature of the septal fluting. From the Hartville formation of Wyoming. (p. 112)

6–9—*Triticites milleri* Thompson, n. sp. *6*, *8*, Axial sections; *7*, slightly oblique tangential section showing the nature of the septal fluting; *9*, sagittal section. From the Hartville formation of Wyoming. (p. 112)

10, *11*—*Fusulina rockymontana* Roth and Skinner? *10*, Axial section; *11*, axial section of a specimen in which two young individuals of only one volution united and developed five outer volutions as one specimen. From the Hartville formation of Wyoming. (p. 109)

12—*Wedekindellina excentrica* (Roth and Skinner). Axial section tangential to the proloculum. From the Hartville formation of Wyoming. (p. 105)



Thompson, Pennsylvanian Fusulinids

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rectly from the genus *Fusulinella*. It is not typical of any one of these three genera, but I am tentatively referring it to the genus *Fusulina*. It seems clear, however, that *Triticites* of the type of *T. irregularis* (Schellwien and Staff) did not develop from this type of forms but was derived from *Fusulinella* of a group like *F. primaeva* (Skinner), *F. pseudobocki* (Lee and Chen), *F. chuanshanensis* (Lee and Chen), and *F. velmae*, n. sp. *F. plattensis* seems to be very distinct from any other known American species.

Horizon and locality.—The syntypes came from the upper part of an 8-foot bed of brittle, slabby, medium-gray limestone, about 300 feet above the level of the lake, 450 feet above the Mississippian limestone, three-fourths of a mile west of the dam, on the west bluff of North Platte River, north of Guernsey, Wyoming.

FUSULINA sp.

Plate 14, figures 23, 24

I have obtained twelve sections of a form which resembles in many respects *F. plattensis*, n. sp., with which it is found associated, but the two groups of specimens do not seem to me conspecific. I do not have sufficient material on which to base a specific description or determination, but it seems advisable to illustrate some of these specimens and to include a brief description of them for the sake of completeness.

My largest specimen of six volutions has a width of about 1.6 mm. and a specimen of five volutions has a length of about 3.2 mm. and a width of about 1.2 mm. The profile of the shell is quite similar for all volutions and the lateral slopes are slightly convex. The poles are rather sharply pointed.

The septa are moderately thick for the genus and they are highly and narrowly fluted throughout the length of the shell. The septal count for the first five volutions of one of my specimens gives 9, 15, 21, 25, and 30. The proloculum has an inside diameter of about 87 microns. From the first to the sixth volution the rate of expansion is rather uniform.

The spirotheca has a structure typical of the genus, but the tectoria are very thin and the diaphanotheca is unusually thick. The diaphanotheca is 28 microns thick in the fourth volution, but in the first volution it is extremely thin.

The tunnel is rather high and narrow and the tunnel angle is about 30° in the fifth volution. The chomata are only very weakly developed and they are essentially symmetrical throughout the shell.

Remarks.—This form resembles in general appearance the specimens figured by Roth and Skinner as the syntypes of their species *F. hartvillensis* and *F. minutissma*, and they may all be conspecific. However, the illustrations and descriptions of Roth and Skinner's specimens are not adequate for detailed specific comparisons. From the published data I cannot separate specifically the two figured specimens on which these two names rest. The measurements given by these authors for their specimens agree very closely with the measurements of my specimens, but their illustrations (with stated magnifications of ×20) show much smaller specimens than my specimens of an equal number of volutions.

The specimens on which this description is based have much more highly fluted septa than *F. plattensis*, have different chomata, and have quite different inner volutions.

Horizon and locality.—The specimens on which this discussion is based came from the upper part of an 8-foot bed of brittle, slabby, medium-gray limestone, about 300 feet above the level of the lake, 450 feet above the Mississippian limestone, three-fourths of a mile west of the dam, on the west bluff of North Platte River, north of Guernsey, Wyoming.

Genus TRITICITES Girty

TRITICITES SUBMUCRONATA Thompson, n. sp.

Plate 16, figures 2–5

Shell small, elongate uniformly fusiform. Poles rather sharply pointed. Lateral slopes low and uniform. Mature forms consist of six to seven volutions. Typical specimens of six volutions are about 4.5 mm. in length and 1.6 mm. in width. Specimens of five volutions are about 3.7 mm. in length and 1.3 mm. in width. The form ratio is about 1:3 for the fifth and sixth volutions.

The septa are rather thin and are very numerous. The septal count gives about 11 for the first volution, 16 for the second volution, 19 for the third volution, 24 for the fourth and fifth volutions, and 26 for the sixth volution. The septa are strongly fluted in the extreme polar regions but they are only slightly fluted in their lower portions near the tunnel.

The proloculum is small and its inside diameter measures only about 75 microns. The rate of expansion of the shell is rather uniform. The heights of the first six volutions are 44, 53, 88, 105, 175, and 210 microns.

In the inner two volutions the spirotheca is very thin, but in the outer volutions it becomes relatively thick. In the third, fourth, fifth, and sixth volutions its thickness is 15, 35, 44, and 70 microns, respectively. The keriotheca definitely has an aveoli structure, but the preservation is such that the alveolar are not very distinct.

The tunnel is low and rather wide. The tunnel angle is about 34° in the sixth volution. The chomata are well developed. In the inner two or three volutions they are somewhat asymmetrical but in the outer volutions they became more nearly symmetrical and in the fifth volution of forms of six volutions they are over one-half the height of the chambers and about one-third as high as wide.

Remarks.—Triticites submucronata more nearly resembles *Triticites milleri*, n. sp., than any other known representative of this genus in America. It can be distinguished from the latter by its smaller tunnel angle, more rapidly expanding volutions, more numerous septa, and larger shell.

Horizon and locality.—The syntypes came from a hard red crystalline limestone on the west bluff of North Platte River, near the north end of the canyon, about 280 feet above the river, in sec. 8, T. 30 N., R. 68 W., about 8 miles southeast of Orin Junction, Wyoming.

TRITICITES MILLERI Thompson, n. sp.

Plate 16, figures 6–9

Shell small, very evenly fusiform. Poles sharply pointed. Mature forms of six volutions are about 3.6 mm. in length and 1.4 mm. in width. The form ratio is 1:2 for the fourth volution, 1:2.8 for the fifth volution, and 1:2.5 for the sixth volution. The shell is very symmetrical throughout all volutions and the lateral slopes are very even.

The septa are rather thin. The septal count of a typical specimen gives 10 for the first volution, 13 for the second volution, 16 for the third and fourth volutions, 15 for the fifth volution, and 20 for the sixth volution. The septa are rather strongly fluted in the extreme polar regions but their basal portion is only slightly wavy across the mid-portion of the shell.

The proloculum is small and its inside diameter measures 50 to 80 microns. The inner two to three volutions of this species are very tightly coiled, but the outer volutions become much more loosely coiled. The heights of the first six volutions are 35, 38, 62, 88, 157, and 245 microns.

The spirotheca is thick. It is clearly composed of only a tectum and a keriotheca, but the preservation is such that the aveoli are not very distinct. The thickness of the spirotheca increases very rapidly in the first six volutions, and in these volutions the spirotheca

measures 7, 13, 18, 35, 62, and 70 microns, respectively.

The tunnel is very low and broad and it is symmetrical. In the sixth volution the tunnel angle is 50° to 54°. The chomata are very well developed in all parts of the shell, except the outer portion of the last volution. They are narrow, high, and symmetrical.

Remarks.—This species resembles rather closely *Triticites submucronata*, n. sp., but it has a larger tunnel angle, more slowly expanding shell, less numerous septa, and a smaller shell for corresponding volutions. In general shape *T. milleri* resembles *T. cullomensis* Dunbar and Condra rather closely, but it is smaller, has a smaller proloculum, and has much better developed chomata than the latter. The variety *T. cullomensis pygmaeus* Dunbar and Condra has been illustrated only by external views and its internal structures are not well known, but the size and shape of the shell correspond very closely to those of *T. milleri*, and the two forms may possibly be conspecific.

Horizon and locality.—The syntypes came from a light-gray, very dense limestone on the west bluff of North Platte River, near the north end of the canyon, about 350 feet above the level of the river, in sec. 8, T. 30 N., R. 68 W., about 8 miles southeast of Orin Junction, Wyoming.

I am naming this species in honor of Dr. A. K. Miller in appreciation of his continued interest and advice throughout my studies of Pennsylvanian fusulinids.

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OSTRACODA FROM THE CHOUTEAU FORMATION OF MISSOURI

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ABSTRACT

The ostracode fauna of the lower Chouteau limestone of Missouri is described. Sixteen species representing nine genera are recorded. *Graphiodactylus granopunctata* and *G. cornuta*, present in the Chouteau, also have been recorded from the Ridgetop shale of Tennessee. *Paraparchites nicklesi*, *Bairdia gibbera*, *B. subparallela*, and *B. magnacurta*, present in the Chouteau, have been recorded from the basal Mississippian sandstone underlying the Chouteau.

The Chouteau formation was named from exposures at Chouteau Springs in Cooper County, Missouri. There is exposed 20 feet of blue-gray limestone overlain by 30 feet of dolomitic limestone. The dolomitic limestone forming the upper part of the Chouteau is now considered to be a separate formation, and has been given the name Sedalia. Detailed paleontologic evidence has not been published to show the correctness of the division, and E. B. Branson, who has made an extensive study of the megafossils of the series, finds no fossil evidence for a division. His report on the paleontology and stratigraphy of the Missouri Kinderhook is now in press.

The outcrops of the Chouteau formation extend across the state of Missouri from northeast to southwest, curving around the central area of the Ozark uplift. In northeastern Missouri the formation is discontinuous and varies greatly in thickness where present. In central Missouri it outcrops more or less continuously and the thickness is less variable. The best exposures in central Missouri have been measured by Moore (1) and others, and detailed sections can be found in his report. The Chouteau can be traced southwest into Hickory County. In the southwestern part of the state beds similar to the lower Chouteau in lithology and fossil content have been called Compton. Beds apparently corresponding to the upper Chouteau have been called Pierson. The Compton and Pierson are separated by a sandstone member, the Northview. All three units contain the same general fauna.

In northeastern Missouri the Chouteau has a thickness of from a few inches to 55 feet. In central Missouri it has a thickness of from 20 to 60 feet. The Compton varies from 12 to 22 feet in thickness and is apparently fairly continuous over the limited area of its occurrence. The Northview is from 30 to 50 feet in thickness, and the Pierson from a few inches to 25 feet in thickness.

The Chouteau (Sedalia) limestone in northeastern and central Missouri is overlain by the Burlington limestone. The Chouteau in central Missouri is underlain by a Mississippian sandstone of Bushberg age. The Pierson is overlain by the Burlington

limestone and the Compton is underlain by an Ordovician limestone.

The Chouteau is a compact, blue-gray, generally thick-bedded limestone. It is fairly resistant to weathering and usually forms steep bluffs and cliff faces where streams cut through it. On exposure to weathering the fresh rock becomes covered by a grayish coating. The Chouteau is abundantly fossiliferous, particularly so in the lower beds, and its age has been definitely established by use of the megafossils. Shale seams are present in the lower part, and from these the samples containing the ostracodes here described were taken.

The collecting localities are as follows: near Brown's Station, 3 miles northwest of the town at the junction of Lost and Clear Fork creeks; Providence, 200 to 500 yards south of the station along the M. K. and T. R. R. tracks; Ozark, north edge of the town.

The ostracode fauna of the Chouteau contains several established species. Of these *Paraparchites nicklesi* is present throughout the Mississippian and is of no value in close correlation. Two species figured by Ulrich and Bassler from the Ridgetop shale of Tennessee are recognized from the Chouteau. One of these species, *Graphiodactylus cornutus*, is abundant in the Chouteau near Brown's Station and at Ozark, Missouri. The specimens from the locality near Brown's Station are consistently smaller than those from Ozark. The other species, *Graphiodactylus granopunctatus*, is present only at Ozark. Several Chouteau species are present in the underlying sandstone of Bushberg age in central Missouri. These species are *Bairdia gibbera*, *B. subparallela*, *B. magnacurta*, and *Paraparchites nicklesi*.

SYSTEMATIC DESCRIPTIONS

Family LEPERDITELLIDAE Ulrich and Bassler, 1906

Genus PARAPARCHITES Ulrich and Bassler, 1906

PARAPARCHITES NICKLESI (Ulrich), 1891

Plate 17, figure 26

Leperditia nicklesi ULRICH, *1891*, Cincinnati Soc. Nat. Hist., Jour., vol. 13, p. 200, pl. 18, figs. 1 *a–c*.

Paraparchites nicklesi GIRTY, *1911*, U. S. Geol. Survey, Bull. 439, p. 105, pl. 9, figs. 2–5.—HARLTON, *1929*, Am. Jour. Sci., vol. 18, p. 255, pl. 1, fig. 1.—MOREY, *1935*, Jour. Paleontology, vol. 9, no. 4, p. 317, pl. 28, fig. 26.

One specimen was found in a sample taken from a thin shale seam about 3 feet above the base of the formation at Brown's Station, Missouri. The specimen is rather large for the species. The tubercle, present only on the left valve, is small and set further from the anterior end of the hinge than it is in most individuals of this species.

Length, 1.78 mm.; height, 0.8 mm.; thickness, 0.63 mm.

Hypotype, Univ. Missouri, 0.1009–1.

Occurrence.—Lower part of the Chouteau formation near Brown's Station Missouri. Also recorded from the basal Mississippian sandstone underlying the Chouteau, and in the Batesville, Moorefield, Fayetteville, Warsaw and Glen Dean formations.

Family KIRKBYIDAE Ulrich and Bassler, 1916

Genus AMPHISSITES Girty, 1910

AMPHISSITES SIMILARIS Morey, n. sp.[1]

Plate 17, figure 6

[1] See note on p. 122.

Carapace compressed laterally; hinge structure, overlap, and lateral outline typical of genus; maximum height at mid-length; anterior dorsal angle obtuse, posterior dorsal angle more nearly a right angle; central node large, approximately circular, with elliptical kirkbyan pit below it; carina at position of anterior node sharp, distinct and slightly curved, extending to within three or four rows of pits of inner ventral carina; posterior node poorly defined with indistinct carina; strong inner ventral carina most prominent below mid-height of valves on the anterior half; a row of large pits is present on both upper and lower sides of inner ventral carina causing it to be broken up and giving it an irregular and bead-like appearance; another row of pits is present on the underside of submarginal carina; inner ventral and submarginal carinae separated from each other by four rows of pits; outer rows of these four are large and almost square; broad border of free edges smooth and concave; surface of carapace coarsely reticulate.

Length, 1.45 mm.; height, 0.5 mm.

Holotype, Univ. Missouri, 0.1009-4.

Occurrence.—Basal Chouteau limestone, Brown's Station and Providence, Boone County; Chouteau limestone, Ozark, Greene County, Missouri. Several specimens were found at each locality.

Genus GRAPHIODACTYLUS Roth, 1929

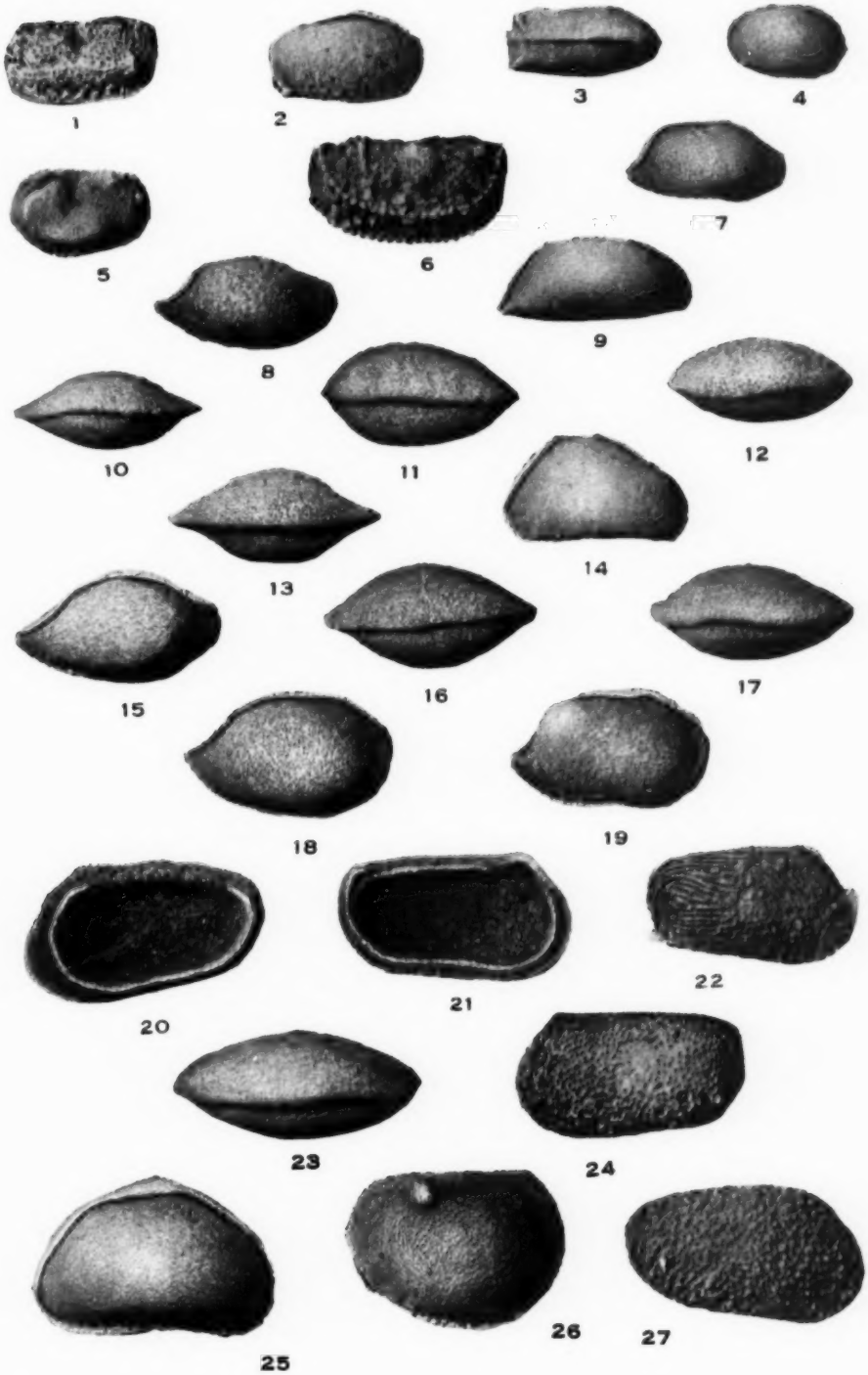
GRAPHIODACTYLUS MINUTUS Morey, n. sp.

Plate 17, figure 4

Carapace small, outline in lateral view subovate; dorsal margin gently convex; cardinal angles of right valve low and rounded but more prominent than those of left valve; sides of carapace fairly evenly convex, reaching maximum convexity in front of mid-length; valves slightly inflated on portions parallel to hinge, inflated portions merging evenly with general convexity of valves; anterior extremity just above mid-height, posterior extremity at or just below mid-height; maximum height just behind mid-length; carapace slightly wedge-shaped in dorsal outline; ventral margin about same convexity as dorsal but

EXPLANATION OF PLATE 17

FIGS. *1*—*Kirkbyella ozarkensis* Morey, n. sp. Right valve view of holotype, ×20. (p. 118)
2, 3—*Healdia decora* Morey, n. sp. *2*, Right valve view of holotype; *3*, dorsal view of holotype, ×20. (p. 121)
4—*Graphiodactylus minutus* Morey, n. sp. Left valve view of holotype, ×20. (p. 116)
5—*Kirkbyella ? dubia* Morey, n. sp. Right valve view of holotype, ×20. (p. 118)
6—*Amphissites similaris* Morey, n. sp. Left valve view of holotype, ×20. (p. 115)
7—*Bairdia subparallela* Morey. Right valve view of hypotype, ×11. (p. 119)
8, 10—*Bairdia gibbera* Morey. *8*, Right valve view of hypotype; *10*, dorsal view of hypotype, ×20. (p. 119)
9, 11—*Acratia similaris* Morey, n. sp. *9*, Right valve view of holotype; *11*, dorsal view of holotype, ×20. (p. 120)
12, 14—*Silenites warei* Morey, n. sp. *12*, Dorsal view of holotype; *14*, right valve view of holotype, ×11. (p. 121)
13, 15—*Bairdia kinderhookensis* Morey, n. sp. *13*, Dorsal view of holotype; *15*, right valve view of holotype, ×11. (p. 120)
16, 18—*Bairdia magnacurta* Morey. *16*, Dorsal view of hypotype; *18*, right valve view of hypotype, ×20. (p. 118)
17, 19—*Bairdia sinuosa* Morey, n. sp. *17*, Dorsal view of holotype; *19*, right valve view of holotype, ×20. (p. 119)
20, 21, 24, 27—*Graphiodactylus granopunctatus* (Ulrich and Bassler). *20*, Internal view of a left valve; *21*, internal view of a right valve; *24*, right valve view of a single valve, *27*, left valve view of single valve, ×20. (p. 117)
22—*Graphiodactylus cornutus* (Ulrich and Bassler). Left valve view of a complete specimen, ×20. (p. 117)
23, 25—*Silenites marginiferus* (Geis). *23*, Dorsal view of hypotype; *25*, right valve view of hypotype, ×20. (p. 121)
26—*Paraparchites nicklesi* (Ulrich). Left valve view of hypotype, ×20. (p. 115)



Morey, Mississippian Ostracoda

slightly inclined toward posterior; ventral portion of carapace not inflated but rather evenly convex to edge; posterior end broadly and almost equally rounded, the dorso-posterior margin being but slightly longer than the ventro-posterior margin; slight smooth carina present on posterior margin of each valve; small tubercle present on antero-ventral surface of each valve; surface of carapace very finely reticulate.

Length, 0.62 mm.; height, 0.4 mm.; thickness. 0.3 mm.

Holotype, Univ. Missouri, 0.1009–3.

Occurrence.—A single specimen was found in the basal portion of the Chouteau limestone at the Brown's Station locality.

GRAPHIODACTYLUS GRANOPUNCTATUS
(Ulrich and Bassler)

Plate 17, figures 20, 21, 24, 27

Paracythere granopunctata ULRICH and BASSLER, *1932*, Tennessee Div. Geology, Bull. 38, pl. 27, fig. 4.

Carapace of medium size, laterally compressed, valves thick; outline in lateral view subrhomboidal; dorsal margin of right valve gently covex except at posterior dorsal angle, which is slightly higher than the adjacent portion of dorsal margin; dorsal margin of left valve fairly strongly convex, ends low and rounded; ventral margins of both valves straight or slightly concave and inclined toward posterior; anterior extremity of carapace above mid-line, posterior extremity below mid-line; hinge straight, formed by slight tooth and socket-type of hinge structure, teeth on smaller left valve and sockets on larger right; in many specimens the sockets are connected by a groove; maximum thickness in front of mid-length; maximum height in posterior half; margin of valves thick, forming a wide, concave inward-facing border; border is widest on the ventro-posterior margin; along the hinge the border is slightly convex and narrower than elsewhere; small spine present on antero-ventral surface below mid-line; surface of carapace granular and rather irregularly punctate.

Length, 1.22 mm.; height, 0.62 mm.

Hypotypes, Univ. Missouri, 0.1009–5.

Occurrence.—Fairly abundant in the Chouteau limestone at Ozark, Greene County, Missouri, and also present in the Ridgetop shale of Tennessee.

GRAPHIODACTYLUS CORNUTUS
(Ulrich and Bassler)

Plate 17, figure 22

Paracythere cornuta ULRICH and BASSLER, *1932*, Tennessee Div. Geology, Bull. 38, pl. 27, fig. 13.

Carapace of medium size, compressed laterally; outline in lateral view subrhomboidal; dorsal margin of carapace very gently convex; ventral margin of carapace slightly concave centrally; dorsal margin of single right valve gently convex in central portion and high and rounded at ends; dorsal margin of single left valve fairly strongly convex; ends of carapace broadly and obliquely rounded; anterior extremity above mid-height of carapace, posterior extremity below mid-height; hinge straight, hinge structure typical of this genus; outline of carapace wedge-shaped in dorsal view; maximum thickness in front of mid-length; outer free edge of right valve overlaps inner free edge of left so that in a complete carapace the free edges seem to meet equally; edges of valves very thick forming wide, inward-facing, concave border, which is widest on the ventro-posterior margin, the wide portion terminates at mid-height of the valve in an upward projecting spine; strong spine present at antero-ventral corner of each valve; surface of carapace strongly marked by more or less regular and continuous subconcentric ridges and furrows.

Length, 1.03 mm.; height, 0.57 mm.

Hypotypes, Univ. Missouri, 0.1010–1.

Occurrence.—Fairly abundant in the Chouteau limestone at Ozark, Greene County, and in the lower Chouteau near Brown's Station, Boone County, Missouri.

Genus KIRKBYELLA Coryell and Booth, 1933

KIRKBYELLA OZARKENSIS Morey, n. sp.

Plate 17, figure 1

Carapace subquadrate in lateral outline; dorsal margin straight in posterior half, gently convex in anterior half; ventral margin very gently convex; posterior margin rounded, limbs of about equal length; posterior dorsal angle obtuse, anterior dorsal angle approximately a right angle; hinge line straight, hinge structure typical of genus; maximum height in posterior half; valves subequal, right valve slightly overlapping free edges of left; sulcus broad and shallow, located just behind middle on dorsal half of valve; ridge begins at posterior end, becomes stronger and better defined toward anterior, reaches maximum strength and terminates abruptly near anterior margin; surface of valves extends posteriorly beyond the posterior contact of the valves; between ridge and ventral border is a single row of seven large square reticulation pits; border wide, concave on ventral edge, narrowest at ends; surface of valves, including ridge, coarsely reticulate.

Length, 0.8 mm.; height, 0.43 mm.

Holotype, Univ. Missouri, 0.1010–3.

Occurrence.—Abundant in the Chouteau limestone at Ozark, Greene County, and in the lower Chouteau near Brown's Station, Boone County, Missouri.

KIRKBYELLA? DUBIA Morey, n. sp.

Plate 17, figure 5

Carapace small, outline in lateral view subrectangular; dorsal margin straight; hinge straight, valves apparently meeting equally; overlap just under postero-dorsal angle slightly stronger than elsewhere on free edges and forms a slight hinge structure; posterior end broadly rounded; ventral margin broadly convex; maximum height behind mid-length; maximum thickness below center of carapace; left valve overlaps right on free edges; deep sulcus, just behind mid-length, runs from dorsal margin to mid-height, where it meets a subcentral depression elongate parallel to length of carapace; strong node present on anterior third just under dorsal margin; node present behind sulcus and about one-third of height of carapace from dorsal margin, a ridge curves backward and downward from this node; below subcentral depression a ridge-like swelling runs anteriorly, ending about one-third length of carapace from anterior end; surface covered by coarse, polygonal reticulation pits which are worn off on the more prominent portions of the carapace. This is evidently an old individual.

Length, 0.72 mm.; height, 0.44 mm.; thickness, 0.35 mm.

Holotype, Univ. Missouri, 0.1009–2.

Occurrence.—Basal Chouteau near Brown's Station, Missouri. Only one specimen was found.

Family BAIRDIIDAE Brady and Norman, 1892

Genus BAIRDIA McCoy, 1844

BAIRDIA MAGNACURTA Morey

Plate 17, figures 16, 18

Bairdia magnacurta MOREY, *1935*, Jour. Paleontology, vol. 9, no. 4, p. 323, pl. 28, fig. 22.

Capapace short, thick, tumid, with a broadly arched dorsal margin; posterior slope of dorsal margin long and slightly concave; anterior slope shorter than posterior and gently convex; ventral margin broadly convex; hinge less than one-half length of carapace and inclined slightly backward; hinge line slightly impressed; periphery of left valve well outside that of right except on antero-ventral margin; actual overlap slight except in central portion of ventral margin, where it is strong; no overlap apparent on antero-ventral margin; sides of carapace strongly tumid behind mid-length at and below mid-height; maximum height just in front of mid-length; maximum thickness just behind mid-length; surface of carapace smooth.

Length, 1.1. mm.; height, 0.7 mm.; thickness, 0.55 mm.

Remarks.—*Bairdia compacta* Geis as figured appears to be similar to this species. However, specimens from the Salem at Spergen Hill identified as *B. compacta* show that the Salem species is tumid above the mid-line, has a straight ventral margin, and is relatively smaller in the posterior half of the carapace than is true in *B. magnacurta*.

Hypotypes, Univ. Missouri, 0.1012–4.

Occurrence.—Abundant in the lower part of the Chouteau limestone at Brown's Station and Providence, Boone County, Missouri.

BAIRDIA SINUOSA Morey, n. sp.

Plate 17, figures 17, 19

Carapace of medium size, generally tumid, laterally compressed in antero-dorsal portion and tumid in postero-dorsal part; dorsal margin convex, highest portion of carapace in anterior half: hinge equal to about one-half length of carapace, inclined toward posterior; anterior end large, blunt in lateral outline, and broadly rounded; anterior extremity just above mid-height; posterior end short, acute, extremity well below mid-height; ventral margin concave in central portion; maximum thickness approximately central; overlap of left valve on right fairly strong except along hinge; periphery of left valve well outside that of right on middle and anterior portions of dorsal margin, but approximately equal on posterior portion; surface of valves smooth.

Length, 1.00 mm.; height, 0.6 mm.; thickness, 0.5 mm.

Remarks.—This species is readily distinguished from *B. magnacurta* by the concave ventral margin and by the strongly inflated postero-dorsal portion.

Holotype, Univ. Missouri, 0.1015–5.

Occurrence.—Rare in the basal Chouteau limestone near Brown's Station, Missouri.

BAIRDIA SUBPARALLELA Morey

Plate 17, figure 7

Bairdia subparallela MOREY, *1935*, Jour. Paleontology, vol. 9, no. 4, p. 323, pl. 28, fig. 24.

Carapace above medium size, with low, broadly convex dorsal margin; anterior slope essentially straight, posterior slope longer than anterior and slightly concave, inclined at a steep angle; slight concavity present in ventral margin just in front of mid-length; this concavity marks a fairly strong overlap of the left valve on the right; central portion of ventral contact long and straight and parallel to hinge; hinge slightly impressed, equal to about three-sevenths total length of carapace, and inclined slightly toward the posterior end; near the dorsal margin, just under the posterior end of the hinge, the valves are quite tumid, much more so than elsewhere near the margins; this tumidity extends downward diagonally across the carapace, ending rather sharply in the anterior half; dorso-anterior portion of carapace somewhat compressed; anterior end laterally compressed and long; posterior end short, compressed laterally, and sharp; sides of carapace strongly convex; maximum height and thickness just in front of mid-length; overlap of left valve on right fairly strong on anterior and posterior slopes of the dorsal margin and in the concavity of ventral margin; overlap weak over ventral margin other than in ventral concavity; surface of carapace smooth.

Length, 1.43 mm.; height, 0.8 mm.; thickness, 0.5 mm.

Hypotypes, Univ. Missouri, 0.1012–5.

Occurrence.—The holotype is from the basal Mississippian sandstone underlying the Chouteau limestone; five distorted specimens, including the one figured here, were found in the Chouteau limestone near Brown's Station, Boone County, Missouri.

BAIRDIA GIBBERA Morey

Plate 17, figures 8, 10

Bairdia gibbera MOREY, *1935*, Jour. Paleontology, vol. 9, no. 4, p. 323, pl. 28, fig. 12.

Carapace of medium size with a highly arched dorsal margin; posterior slope of dorsal margin deeply concave; anterior

slope longer than posterior and very slightly concave; ventral margin broadly and rather evenly convex; small posterior end attenuate, rather sharply set off by a pronounced concavity in posterior dorsal slope; long anterior end laterally compressed and rather narrow in comparison to strongly tumid part of carapace behind it; hinge short, about one-third total length of carapace, slightly impressed and inclined slightly toward posterior; upper surfaces of valves equal in height along hinge, so that periphery of left valve is not outside that of right along that portion; on anterior and posterior slopes of dorsal edge, left valve overlaps right fairly strongly; overlap on ventral edge very slight, edges of valves meeting almost equally; maximum height in front of mid-length; maximum thickness approximately through center; surface of carapace smooth.

The figured specimen from the Chouteau differs from the holotype (from an underlying sandstone) in having a less narrow anterior end, a more attenuate posterior end, and in being less tumid in the region adjacent to the hinge.

Length, 0.95 mm.; height, 0.5 mm.; thickness, 0.41 mm.

Hypotypes, Univ. Missouri, 0.1015–3.

Occurrence. — Chouteau limestone, Brown's Station, Missouri.

BAIRDIA KINDERHOOKENSIS
Morey, n. sp.

Plate 17, figures 13, 15

Valves thick; carapace large with well arched dorsal margin; posterior slope of dorsal margin long, concave in lower part, and slightly convex in upper; anterior slope shorter than posterior and indented about one-third of its length from anterior extremity; ventral margin broadly and evenly curved to about one-third of length from anterior end where it bends upward abruptly; this point of sharp upturning is about the same distance from the anterior end as the indentation in the anterior dorsal slope, and the two features set off the anterior end from the evenly curved margins of the carapace; anterior end further set off by being strongly compressed laterally while the central portion of the carapace is strongly tumid; posterior end fairly long and produced to a point; hinge horizontal, slightly impressed, short, slightly more than a third the total length of the carapace; edge of left valve along hinge very thick; left valve overlaps right strongly on dorsal margin, except along hinge, where there is no overlap; overlap also strong on central portion of ventral margin and slight between that portion and the ends; maximum height at mid-length; maximum thickness at center; surface of carapace smooth.

Length, 1.91 mm; height, 1.1 mm.; thickness 0.7 mm.

Holotype, Univ. Missouri, 0.1012–3.

Occurrence.—Abundant in the Chouteau limestone near Brown's Station and at Providence and Ozark, Missouri.

Genus ACRATIA Delo, 1930

ACRATIA SIMILARIS Morey, n. sp.

Plate 17, figures 9, 11

Carapace about medium size, compressed dorso-ventrally; dorsal margin broadly convex; anterior and posterior slopes of dorsal margin fairly strongly convex; anterior end short and narrowly rounded; posterior end short and rather acuminate; ventral margin gently convex, with broad central concave portion; maximum length essentially along ventral margin; hinge, equal to a little less than one-half total length of carapace, inclined very slightly toward anterior; sides of carapace strongly convex, giving carapace in dorsal view a broadly subovate outline; ventral surface of carapace wide and flattened; left valve overlaps right except along hinge; maximum height at mid-length; maximum thickness in posterior half; surface of carapace smooth.

Length, 1.0 mm.; height, 0.4 mm.; thickness, 0.64 mm.

This species differs from *Acratia deloi* Geis in having the position of greatest thickness behind the mid-length.

Holotype, Univ. Missouri, 0.1010–5.

Occurrence.—Chouteau limestone at Providence and near Brown's Station, Boone County, Missouri.

Genus SILENITES Coryell and Booth, 1933

SILENITES MARGINIFERUS (Geis)

Plate 17, figures 23, 25

Bythocypris marginifera GEIS, *1932*, Jour. Paleontology, vol. 6, no. 2, p. 179, pl. 26, figs. 2 *a*, *b*.

Carapace above medium size, dorsal margin well arched; anterior and posterior slopes of dorsal margin subequal in length, posterior slightly longer and more convex; ventral margin strongly concave near mid-length of carapace; both anterior and posterior ends broadly rounded; hinge very slightly impressed, equal to a little less than one-half total length of carapace, inclined toward posterior, anterior end of hinge slightly in front of mid-length; sides of carapace fairly strongly but evenly convex; left valve overlaps right slightly on all edges; periphery of left valve well outside edge of right; maximum height just in front of mid-length; maximum thickness through center; surface of carapace smooth.

The specimen here described is not a mature one. The rather sharp apex of the dorsal margin seems to be peculiar to this specimen; no such condition was observed in other specimens at any stage in development. In general, the Chouteau specimens seem to be shorter in proportion to the length of the anterior end than is true of the Salem species. The figured specimen is the only one of about 25 specimens that was not distorted, and it is figured for this reason.

Length, 1.26 mm.; height, 0.77 mm.; thickness, 0.53 mm.

Hypotypes, Univ. Missouri. 0.1015–2.

Occurrence.—Basal Chouteau limestone, near Brown's Station, Missouri; a few specimens were found at Providence, Missouri.

SILENITES WAREI Morey, n. sp.

Plate 17, figures 12, 14

Carapace large; outline in lateral view subtriangular; dorsal margin well arched; anterior slope of dorsal margin straight and slightly longer than the posterior slope; posterior slope slightly convex; ventral margin essentially straight; long anterior end set off by straightness of dorsal slope and ventral margin; posterior end shorter than anterior, extremity well below mid-height; hinge short, equal to about one-third total length of carapace, inclined at a low angle toward posterior; left valve overlaps right slightly on all edges except along hinge; strongest overlaps on anterior and posterior slopes of dorsal margin and on center of ventral edge; maximum height and thickness at mid-length; sides of carapace of medium convexity; surface of carapace smooth.

This large species is distinguished from *S. marginiferus* by its long anterior end and its straight ventral margin. These characteristics are constant through all growth stages. The figured specimen is slightly broken at the posterior end and at the extreme dorsal portion.

Length, 1.7 mm.; height, 0.96 mm.; thickness, 0.77 mm.

Holotype, Univ. Missouri, 0.1015–1.

Occurrence.—Lower part of the Chouteau limestone near Brown's Station, Missouri.

Genus HEALDIA Roundy, 1926

HEALDIA DECORA Morey, n. sp.

Plate 17, figures 2, 3

Carapace narrow and elongate, with nearly parallel dorsal and ventral margins; dorsal margin gently arched, anterior and posterior slopes gently convex, the posterior longer than the anterior and appearing truncate in lateral view; ventral margin broadly and gently convex; outline of posterior end blunt and angular in both lateral and dorsal views;

outline of carapace wedge-shaped in dorsal view, sides of posterior two-thirds almost parallel, sides of anterior curving evenly to anterior end; anterior end in lateral view broadly rounded; left valve overlaps right slightly on ventral and dorsal edges, except on posterior dorsal edge; valves appear to meet equally at ends, but single valves show a "lip and lip" type of marginal relation, with the outer "lip" on left valve; ridge begins at dorsal margin behind mid-length and runs backward and downward to ventral margin, where it bends slightly toward front; ridge divides posterior from lateral surface and forms posterior margin of valve in lateral outline; spine present on ridge near ventral margin; surface of carapace smooth.

Length, 0.83 mm.; height, 0.46 mm.; thickness, 0.37 mm.

Syntypes, Univ. Missouri, 0.1015–5.

Occurrence.—Fairly abundant in the lower part of the Chouteau limestone near Brown's Station, Missouri.

REFERENCE

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NOTE.—The ornamentation of *Amphissites similaris*, as described in this paper, and of *A. centronotoides* Geis is similar to that of the common Pennsylvanian species *A. centronotus*. Mr. Geis and I agree that until better material on which study of the relationships of these forms can be based, *A. similaris* and *A. centronotoides* should be considered as subspecies of *A. centronotus*.

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SOME FUSULINID PROBLEMS

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ABSTRACT

The finding of microspheric individuals of a number of species belonging to different genera of fusulinids has resulted in some confusion, particularly with reference to *Schubertella*. In the hope of clarifying these difficulties, the microspheric forms of various observed types are contrasted with *Schubertella*. Examples of cytogamy, which is another potential source of confusion, are also described.

At the sixth annual meeting of the Society of Economic Paleontologists and Mineralogists in March, 1932, I gave a short talk entitled *Fusulinid sports*. The abstract of this paper was as follows.

From approximately 2,500 thin-sections, a very limited number were noted, illustrating three types of sports in both the more primitive groups characterized by *Fusulina* and that by *Triticites*. The first type possesses a double proloculum; the second, ten or more planispiral, spherical chambers following the spherical proloculum; the third, a form which, in its early stages, possesses two distinct individuals, developing more or less independently for two or more whorls, only to lose their individuality by whorls common to both in later volutions.

In presenting this subject, mention was made of existence of the multilocular, planispiral, spherical chambered portion as a complete unit within the chamber cavity of the late whorls of some specimens of fusulinids, and not as the primordial stage as portrayed in the illustrations given. Neither the importance nor the proper significance of these forms was realized at the time they were presented. They were discussed in order to prevent their appearing as new species or genera and to avoid confusion in understanding of the development of the fusulinids as a whole by improperly relating them to *Schubertella*. For this latter purpose, a true *Schubertella* was illustrated for comparison.

In an unpublished monograph on *The Fusulinidae of the Ardmore Basin*, completed in April, 1934, these forms were taken up again and discussed, and what seems to be their proper significance was indicated. The fact that microspheric forms in the lower group have been found by M. L. Thompson and described as a new species, possibly of a new genus, *Fusulina? problematica* Thompson (*Univ. Iowa Studies*, vol. 16, No. 4, Oct., 1934), and that microspheric forms have been discovered also among the higher groups and described before the Paleontological Society (Rochester meeting, December, 1934, C. O. Dunbar, J. W. Skinner and R. E. King, *Dimorphism in Permian fusulines*), in such a fashion as to question the existence of *Schubertella* and the scheme of evolution as adopted by me and others, makes it advisable to present the matter at

this time without awaiting publication of my paper.

My views regarding evolution of the fusulinids as expressed in *Some Texas Fusulinidae* (*Univ. Texas, Bull.* 3211, March 15, 1932), have not changed in any essential particular. The establishment of any scheme of classification based upon evolution is obviously a very difficult task, due in great part to the fact that proper understanding must be based on vital features, which, nevertheless, are not as easily recognizable as some feel they should be to warrant their being called vital. For example, I think all will grant that arenaceous and fibrous, hyaline and porcellaneous shells, cannot be grouped even under the same family, and yet workers on the Fusulinidae do not always agree on the fundamental nature of the wall. In view of this fact, I do not feel warranted in going into the more important question of further proof of the classification put forward by me until such time as I am permitted to present the full evidence.

The unusual forms presented here have been observed in both the lowest group typified by the genus *Fusulina* and the higher group typified by the genus *Triticites*. Thompson has found the microspheric form in *Fusulina*. One specimen of the microspheric form of *Schwagerina* has been found by me and specimens of *Parafusulina* and possibly *Polydiexodina* by Dunbar, Skinner and King. It is to be expected that the microspheric form will be found in all species. Since my studies have been practically confined to the Lower Pennsylvanian forms, they only are used for illustration.

Shells belonging to the genus *Fusulina*, but possessing two prolocula, are shown on Plate 19, figs. 8, 9, and Plate 20, fig. 3. Each of these develops its own independent set of chambers for a few whorls and then builds a set of chambers common to both in the later whorls. This,

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EXPLANATION OF PLATE 18

FIGS. *1*—Camera-lucida pencil sketch of a *Staffella*, ×140, drawn at 220 diameters. Same specimen as Plate 19, fig. *1a*.

2—Camera-lucida pencil sketch of the primordial stage of a primitive *Schubertella*, ×140, drawn at 220 diameters. Same specimen as Plate 19, fig. *2*.

3—Camera-lucida pencil sketch of the primordial stage of a less primitive *Schubertella* from a higher stratigraphic horizon, ×140, drawn at 220 diameters. Same specimen as Plate 19, fig. *3*.

4, 5—Camera-lucida pencil sketches of the primordial stage of a specimen of *Fusulina primaeva* (Skinner). *4*, Sketch ×140, drawn at 220 diameters. Same specimen as Plate 19, fig. *4*, though from opposite side of slide. *5*, Camera-lucida pencil sketch of same specimen, ×30.

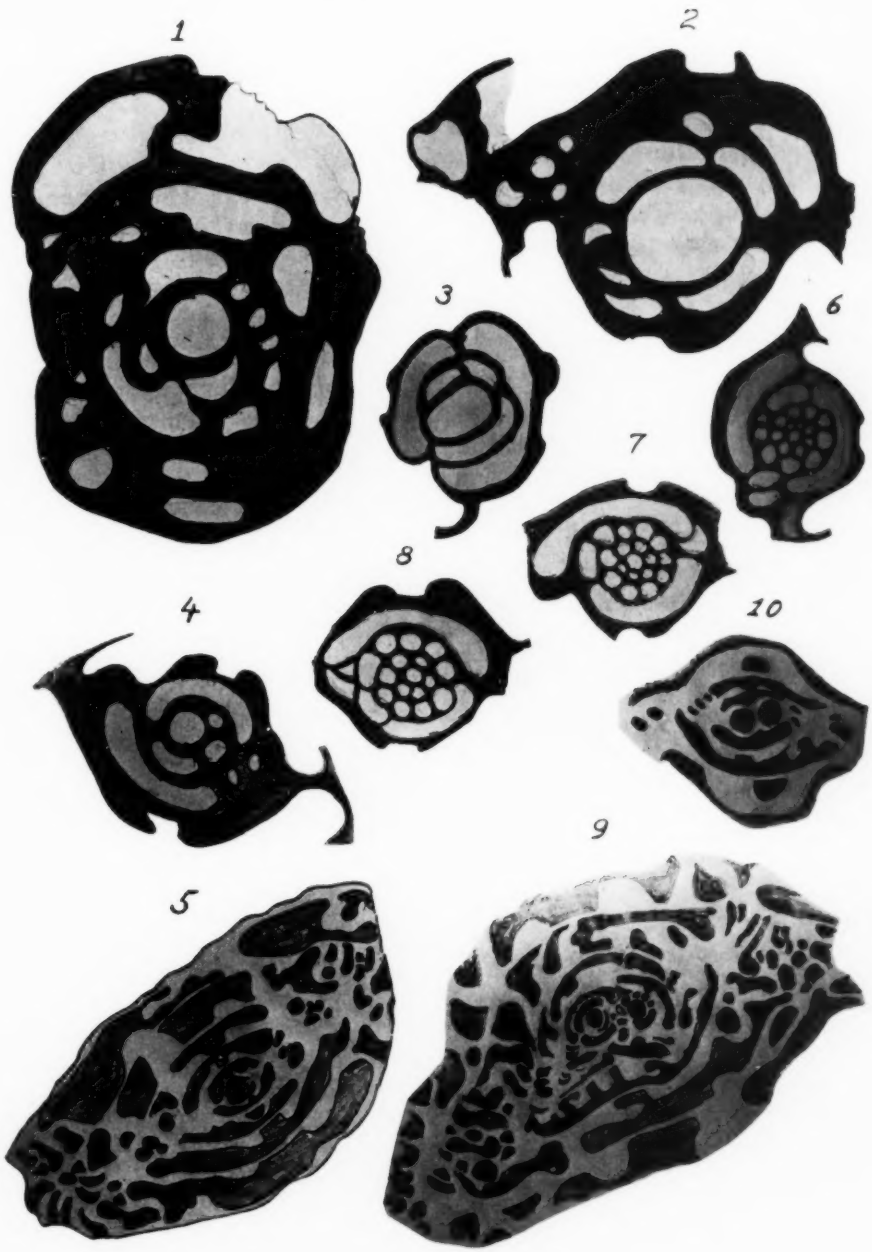
6—Camera-lucida pencil sketch of the primordial stage of the microspheric form of a species of *Fusulina*, ×140, drawn at 220 diameters. Same specimen as Plate 19, fig. *5*.

7, 8—Camera-lucida pencil sketches of the primordial stages of specimens of the genus *Triticites*, ×140, drawn at 220 diameters. Same specimens as Plate 19, figs. *6*, *7*.

9—Camera-lucida pencil sketch of a specimen of *Triticites* showing cytogamy, ×30. Same as Plate 20, fig. *1*.

10—Camera-lucida pencil sketch of the primordial stage of a specimen of the genus *Triticites* showing rudimentary cytogamy, ×65. Same specimen as Plate 20, fig. *2*.

NOTE: Figures *1–4* and *6–8* are same magnification.



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I believe, is an example of cytogamy or plastogamy, the union of the protoplasm without nuclear union or identical twins produced from the same egg, the existence of which has long been questioned in foraminifera. Similar forms belonging to the genus *Triticites* are illustrated on Plate 18, fig. 9, and Plate 20, figs. 1, 5.

Specimens of *Triticites*, possessing a double proloculum are shown on Plate 18, fig. 10, and Plate 20, figs. 2 and 4. These are probably examples of cytogamy of a more rudimentary form.

The microspheric form of a species of *Fusulina* is illustrated on Plate 18, fig. 6, and Plate 19, fig. 5. The microspheric form of a species of *Triticites* is shown on Plate 18, figs. 7, 8, and Plate 19, figs. 6, 7. The principal distinguishing characteristic of these microspheric forms lies in the possession of a primordial stage, represented by ten or more planispirally coiled spherical chambers before the development of the usual form of chamber.

The discovery by Dunbar of microspheric forms placed by him in the genus *Parafusulina*, caused him to suggest that the discovery of microspheric forms, coupled with the failure to recognize them as such, had led to acceptance of the validity of the genus *Schubertella*. The proper interpretation of the question has a vital bearing on the understanding of the Fusulinidae as a whole, which fully warrants any clarification that can be made.

In order more successfully to contrast the genus *Schubertella* with the microspheric form of any of the fusulinid genera, and to relate all properly, it is best to start with a consideration of *Staffella*, the ancestor of *Schubertella*. Owing to the long range of *Staffella*, a natural corollary to its primitive nature, and the resulting lack of value as a guide fossil, I have given it only such consideration as I felt was necessary to the proper understanding of the development of the Fusulinidae as a whole. A simple definition of the genus *Staffella* is that it is a fusulinid with a four-part wall that retains evidence of its development out of *Endothyra*, as shown by its endothyroid early stage. Also, in *Staffella* the test is still nautiloid or spheroid, with the axial diameter shorter at all stages. When the axial diameter becomes longer, the development has reached the stage where it automatically becomes a *Schubertella*.

Any worker who adopts a natural scheme of classification expects to find that more primitive forms outrange their more specialized offspring and to find the primitive forms less satisfactory as guide fossils in direct proportion to their simplicity. Personal observation indicates that *Staffella* out-ranges *Schubertella* and that either out-ranges any other genus of fusulinids with the exception of *Orobias*, an even more primitive form. My work has dealt principally with the lower fusulinids, which possibly accounts for the fact that all specimens of both *Staffella* and *Schubertella* observed by me have possessed the four-part wall. However, it is not difficult to realize that

paralleling the development of *Fusulina*, these genera may progress to the stage in which one or the other, or both, depositional layers are lost. It is not considered impossible that development may also take place in such fashion that the endothyroid early portion is lost, either before or after loss of the depositional layers. But if loss of the endothyroid stage occurs before loss of the inner and outer depositional layers, the resulting form would be indistinguishable from *Fusulina*. If Staff and Wedekind's type figures of *Schubertella* may be accepted, the one which is popularly interpreted as microspheric, has already lost its inner depositional layer and the one which is interpreted as being megalospheric has, in addition, lost its endothyroid early stage. After the evidence included in this paper has been fully considered, I doubt if one would be willing to consider that this so-called microspheric form is in fact microspheric. The so-called megalospheric form would be indistinguishable from the transitional forms from *Fusulina* to *Triticites*. If the next stage of development of *Schubertella*, beyond that credited to this megalospheric specimen of *Schubertella* by Staff and Wedekind, is reached, both outer and inner depositional layers, as well as the endothyroid stage, are lost, and a specimen showing these features would be assigned to *Triticites*. The difficulty experienced by many in recognizing the subdivision of the wall, or in separating the diaphanotheca from the tectum in the more primitive forms, further complicates the matter. Though it seems that in the loss of depositional layers, the outer layer generally is lost later than the inner one, this loss is so nearly simultaneous in both layers that I have concluded that erection of a new genus to include these forms which are transitional from *Fusulina* to *Triticites* is unwarranted, and that they had best be included under the former. Similar logic induces me to include the so-called microspheric form of Staff and Wedekind's *Schu-*

EXPLANATION OF PLATE 19

FIGS. *1a*, *b*—Sections of a *Staffella*. Same specimen as Plate 18, fig. *1*. *a*, Longitudinal section, ×40. *b*, Median section of a specimen of the same species which may be taken as typical of a median section of any fusulinid, ×41.

2—Longitudinal section of a primitive *Schubertella*, ×44. Same specimen as Plate 18, fig. *2*.

3—Longitudinal section of a less primitive *Schubertella*, ×33. Same specimen as Plate 18, fig. *3*.

4—Longitudinal section of a specimen of *Fusulina primaeva* (Skinner), ×29, same specimen as Plate 18, figs. *4*, *5*.

5—Longitudinal section of a microspheric specimen of *Fusulina*, ×47. Same specimen as Plate 18, fig. *6*.

6—Longitudinal section of a microspheric specimen of *Triticites*, ×36. Same specimen as Plate 18, fig. 7.

7—Longitudinal section of a microspheric specimen of another species of *Triticites*, ×24. Same specimen as Plate 18, fig. *8*.

8—Longitudinal section of a silicified specimen of *Fusulina primaeva* (Skinner), showing cytogamy, ×31. Same specimen as Plate 20, fig. *3*.

9—Longitudinal section of a specimen of another species of *Fusulina* illustrating cytogamy, ×20.

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bertella, and to exclude the so-called megalospheric form. Withal, I am doubtful of the three-part division of the wall of either. It would have been much more fortunate, to say the least, if the type of the genus had been based upon a form near the middle of its range, a form which would be more typical of a natural subdivision which is a genus. Where it is possible, an effort should be made to do just this before a new genus is erected.

Parallel difficulties may be expected with regard to *Staffella* and this is indicated at least in part by the literature. Here again my observations have included only specimens which fit the simplified description of the genus just given. This may also be due to lack of familiarity with the upper limits of the genus. Here, too, simple logic prompts skepticism regarding similar variation recorded in the literature regarding this genus.

In following the discussion of the features which clearly indicate that the forms here called microspheric are truly microspheric (and by the same evidence in strong contrast to genera possessing the endothyroid early stage), the reader is asked to note also the relative stage of evolution of these features in the form in which they are portrayed. Many points in support of the classification accepted by me as natural, both with regard to relationship of genera and to stratigraphic position, will result. As a suggestion of what is meant, it will be noted that the endothyroid stage is more pronounced in *Staffella* than in *Schubertella*, and in the lower forms of *Schubertella* than in the higher forms. A very rapid and simple method of recognizing this relative state of the endothyroid stage lies in the increase in regularity or symmetry as the endothyroid portion progresses towards extinction.

That this stage of the microspheric form, composed of ten or more planispirally coiled spherical chambers, should not be confused at all with the endothyroid stage of the primitive forms is clear, not only from the nature of that portion alone but from a consideration of the whole test. While *Schubertella* only includes forms with a four-part wall, and possibly a three-part wall, it does not include forms in which the wall is but two-part. The microspheric stage is found in forms possessing the two-part wall, as well as in forms possessing the four-part wall and shows little or no difference between the two.

The proloculum of *Schubertella* is not minute, like that of the microspheric individual, especially if the small size of *Schubertella* is taken into consideration. The microspheric individual is larger than the megalospheric individual of the same species, the divergence increasing upwards with the general increase in size of all forms. There are few, if any, adult specimens of any of the more advanced genera as small as the adult of *Schubertella*. The primordial stage of *Schubertella* involves only a few endothyroid chambers, all of which are rather irregular and not perfectly spherical, in contrast to the microspheric primordial stage. The pro-

loculum of *Schubertella* is much larger than the immediately succeeding endothyroid chambers, while the microspheric proloculum is very little larger than the next succeeding spherical chambers. Where *Schubertella* has been found by me, it occurs in great abundance, which contrasts with the marked rarity that we expect and find with regard to numbers of microspheric individuals. It would not do to say that the finding of abundant shells called *Schubertella* are exceptional cases in which there is great abundance of microspheric individuals, for the small size of the individuals and the relatively large size of the proloculum is in contrast to all cases of bona fide individuals of microspheric form. As a matter of fact, the infrequency of finding *Schubertella* is probably largely due to its small size, and it is mistaken for the young of accompanying forms of *Fusulina*, full-grown specimens of which are naturally selected for sectioning. On the other hand, it is obvious that the microspheric individual, because of its larger size and, at least among the lower forms, its greater tumidity, is singled out for sectioning more often than its relative abundance would warrant.

Thompson's discovery of the microspheric form of *Fusulina*, to which he attaches the name *Fusulina? problematica*, is unique, principally because of its apparent abundance. Though I have made no detailed study of his species, I am of the opinion that they are the microspheric form of his *Fusulina kayi*, with which it is found. Though more tumid, Thompson's microspheric form is given as smaller. This is possibly due to the fact that the smaller number of available specimens has resulted in failure to find gerontic forms such as have been found in the case of *F. kayi*. The listing of fewer volutions for the microspheric form to some extent supports this contention. It is also interesting to note that Thompson referred this microspheric form "very doubtfully" to the genus *Fusulina*, because in his opinion it possessed characteristics used as distinctive of both *Fusulina* and *Fusulinella*, a distinction of genera which for like reasons is not recognized by me.

Apparently because he is not acquainted with microspheric individuals among the lower group of the Fusulinidae, Dunbar has stressed the lack of chomata and thus absence of the tunnel in his microspheric individuals, indicating that this had some bearing on the validity of the classifications adopted by other workers as contrasted with his. I fail to see what contradiction there is in this point, when it is noted that the microspheric individuals illustrated here possess the chomata and therefore the tunnel, differing in no vital particular from the chomata or tunnel in the megalospheric individuals. Further, chomata and tunnel are present in all individuals of *Schubertella* examined by me. In the one discovered microspheric specimen of *Schwagerina*, the chomata and tunnel were present in the early stages and absent in the later stages, just as in the case of the megalo-

spheric individual of the same species. Doctor Dunbar has informed me that this is the case in at least one of his specimens.

According to my opinion, the question of presence or absence of chomata, as stated above, is in no way changed by evidence supplied by the microspheric individual as against that of the megalospheric. It is merely the loss of depositional material in the group as a whole, occurring, first, with the loss of the tectoria, later in the loss of the chomata, and lastly, with the loss of the keriotheca.

It may be that the planispirally coiled spherical chambers of the microspheric individual can be looked upon, at least in part, as evidence of recapitulation, commonly regarded by some as a characteristic feature of the microspheric form.

Two thin-sections show the presence of a series of planispirally coiled spherical chambers, like those of the primordial stages of the microspheric individual of a fusulinid, within the chamber cavity of a megalospheric individual. Both of the specimens in which these were found belong to the genus *Triticites*. These represent the embryonic stage of two microspheric individuals within megalospheric adults. If my interpretation of these specimens is correct, it practically establishes the conclusions of this paper as a whole. The same doubt which confronted me when I first considered the possibility that these were microspheric individuals within the megalospheric host has doubtless occurred to the reader as well. Common conception of the megalospheric form is that it possesses a single nucleus. Nucleoli appear in increasing numbers with growth, the nucleus finally breaks down and a great number of nuclei appear. These draw to themselves portions of the protoplasm and then divide by mitotic division, leaving the test in the form of zoospores, the supposed conjugation of these zoospores giving rise to the microspheric individual. This has yet to be proven by observation and does not account for the great scarcity of microspheric individuals. This conception immediately calls for explanation of the occurrence of a microspheric embryo within the shell of a megalospheric adult. While I do not feel competent to answer this question with complete satisfaction, some reasons for the conclusion that it is the microspheric individual within the megalospheric can be given.

There is no question as to the megalospheric host, nor is the embryo in any way different from that which would be expected in an embryo of a microspheric individual of the same species, and in each case an alternation of generation is present within the single slide.

At any rate, what is here called the embryonic individual of the microspheric form, if it results from conjugation of zoospores, resulted from conjugation of zoospores within the megalospheric host for the simple reason that its proloculum alone is too large to have gained entrance through the perforations or even the so-called pores of the test, providing

the megalospheric individual had "spores." This naturally follows because of the fact that *Triticites* has no external aperture, or in other words, no aperture at all. For proof of lack of external aperture, the reader is referred to my work on *Some Texas Fusulinidae*. It is much simpler to accept the conclusion that the zoospores originated in the megalospheric individual than to ask that they be imported into the living protoplasm of this megalospheric individual from another individual. That the form here called the microspheric embryo did develop in the living megalospheric host is obvious from a consideration of the thin-section, where it occupies the third from the last whorl. If this were not true, and it had developed in the empty test of a dead individual, it would have broken the wall of the whorl in which it grew, and not have bent it, let alone causing the bowing or arching of the two succeeding whorls with which it did not come in contact.

That the retention of the microspheric form within the megalospheric form is unnatural is also obvious from the testimony of this same section. However, the obviousness can only be applied to its retention, not to its formation, within the test rather than outside. It seems likely that conjugation of zoospores outside the test is the usual condition and that the rarity of the microspheric form is due simply to the probability that such conjugation of zoospores to form the microspheric individual is a much rarer process than the gathering of protoplasm by nuclei to form megalospheric individuals.

Specimens of the lowest known *Fusulina* from the Marble Falls outcrop are particularly interesting and enlightening. Many of the specimens from this outcrop are beautifully preserved through silicification.

EXPLANATION OF PLATE 20

FIGS. *1*—Longitudinal section of a specimen of *Triticites* illustrating cytogamy, ×18. Same specimen as Plate 18, fig. *9*.

2—Longitudinal section of a specimen of another species of *Triticites* illustrating rudimentary cytogamy, ×40. Same specimen as Plate 18, fig. *10*.

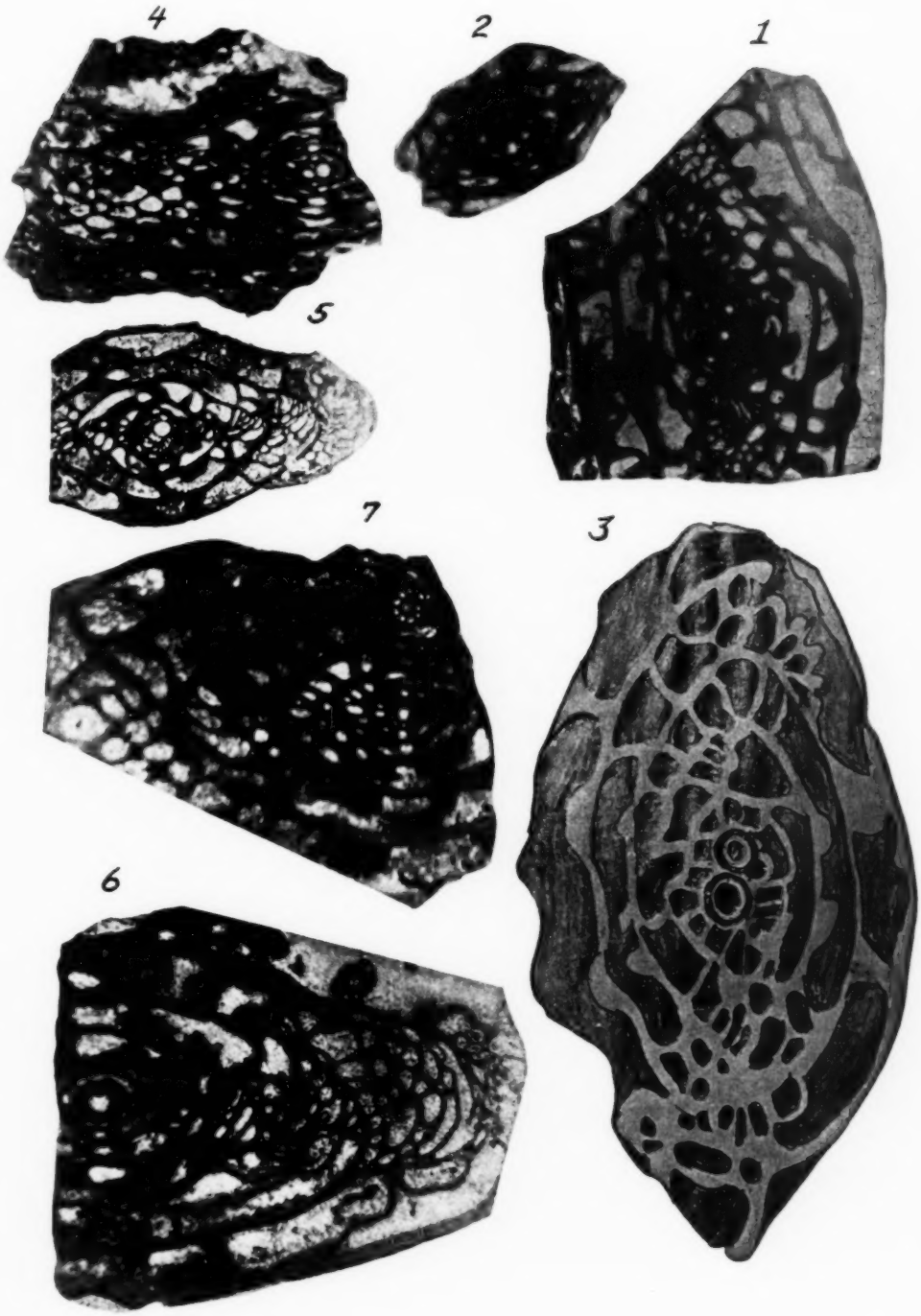
3—Camera-lucida pencil sketch of a specimen of *Fusulina primaeva* (Skinner) illustrating cytogamy, ×50. Same specimen as Plate 19, fig. *8*.

4—Longitudinal section of a specimen of a third species of *Triticites* showing rudimentary cytogamy, ×21.

5—Longitudinal section of a specimen of a fourth species of *Triticites* showing cytogamy, ×16. This section was impossible to orient so as to see both proloculi properly. It is a median form between the rudimentary and the more advanced examples given.

6—Longitudinal section of a megalospheric specimen of a species of *Triticites* in the seventh or last whorl of which can be seen the primordial stage of a microspheric individual, ×41.

7—Longitudinal section of a megalospheric specimen of another species of *Triticites* in the fifth or third from the last whorl of which can be seen the primordial stage of a microspheric individual, ×38. In this section, in order to get as near orientation of both proloculi as possible, the section did not reach the center of the megalospheric individual, but went beyond the center of the microspheric (indicated by the elongate nature of the later chambers and that what appears to be the proloculum is, in fact, the proloculum plus one whorl of spherical chambers). Note the microspheric individual has grown enough to warp the walls of the host.



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Because the perfection of preservation has made the fibers so obvious, it was first identified as *Triticites?* sp. by one of the workers who believes that such structural characteristics do not develop until *Triticites* is reached. Much of my material was supplied by Mr. Norman L. Thomas, who identified the specimens as *Fusulina primaeva* (Skinner). At the time, Mr. Thomas referred specimens to Doctor Dunbar, who considered them as belonging to *Fusulinella*. However, Mr. Skinner called them *Fusiella*. Not recognizing *Fusulinella* or *Fusiella*, I concur with Mr. Thomas. As to presence of a three-part or four-part wall, I agree with Thomas and Dunbar that it has the four-part wall and make such an interpretation even from Plate 30, fig. 9, used by Skinner in his description of the species to illustrate the existence of a three-part wall.

Of the dozen or more thin-sections which I made of this species, two are included in the unusual fusulinids considered here. One has already been called to attention as showing cytogamy. Another (Plate 18, figs. 4, 5, and Plate 19, fig. 4) is again presented as a possible representation of recapitulation, or as a form which is neither *Schubertella* nor one that has yet developed to the true *Fusulina* stage. It is a much more difficult specimen to evaluate. Considered by itself, I should not hesitate to call it *Schubertella*. However, such a procedure is questionable. If it were properly assignable to *Schubertella*, one would expect it to be in sufficient abundance that Mr. Thomas would have found specimens. Mr. Skinner does indicate that he found them by saying, "The present species does not possess an oblique nucleoconch except in a few infrequent cases." On the other hand, it is stated of Lee and Chen's genotype of *Fusiella*, *F. typica*, that the "first series of chambers are either endothyroid or irregularly rolled up around the proloculum." In my opinion this form is a *Schubertella* smaller than *F. primaeva*. *Fusulina primaeva* (Skinner) is a somewhat more advanced form in which rare specimens have a hold-over endothyroid nucleoconch. This would not be at all startling if the natural scheme of classification accepted by me is followed, for *F. primaeva* is the lowest *Fusulina* known, and it is nearest to the horizon at which *Fusulina* first develops from *Schubertella*. If we attempt to separate these Marble Falls specimens into *Schubertella* and *Fusulina*, we face the rather disconcerting situation of being unable to employ in our description unsectioned specimens of either, as it would be impossible to tell, without some unknown use of X-rays or the like, to which one of the two an unsectioned specimen belonged. This difficulty is a common one in dealing with the transitional stages between any natural subdivision.

As to the three-part instead of four-part division of the wall, aside from the fact that observations by Thomas, Dunbar and me indicate the four-part division of the wall, simple logic supports the conclusion

of a four-part wall. The belief in the three-part as against the four-part wall is based on the assumption of the absence of the diaphanotheca in these particular forms. Is it not difficult to picture the absence of the diaphanotheca when it is recalled that the diaphanotheca and the tectum form the middle portion of the *Fusulina* wall? This is especially true when it is remembered that the tectum is always very thin, even in much higher forms, and that the diaphanotheca plus the tectum is thinnest in the lowest forms. Also the tectum and diaphanotheca become thicker, both actually and in relation to the thickness of the whole wall, because of the gradual disappearance of the two outer depositional layers as the evolution of the group is followed upward through a transitional stage in which three parts are present (tectum, diaphanotheca, and only one depositional layer) to forms in which two divisions are present (diaphanotheca or keriotheca, and tectum), and still farther to a form in which only the tectum is left. Is it not more logical to assume that the observations of Thomas, Dunbar and me are correct; that the extreme thinness of the diaphanotheca and the tectum, and particularly of the tectum alone, has resulted in the failure to recognize the tectum rather than the diaphanotheca, and further, to separate the two? If not, we are faced with the additional dilemma of a progressive evolution in which we start with a thick tectum, progress backwards to a thin tectum and forwards again to a tectum increasing in thickness beyond any of the preceding ones, from a three-part wall to a four-part wall and back to a three-part wall.

The specimen of *Fusulina primaeva* with the endothyroid nucleoconch also differs from the other forms which are recognized here as microspheric individuals. True, it has almost, though not quite, the rarity of a microspheric individual, but it has the scarcity in numbers and irregularity of shape in its endothyroid chambers which contrasts so markedly with the primordial state of the microspheric individual. Though its proloculum is but 0.04 mm., while the accompanying specimens of *F. primaeva* range from 0.07 to 0.135 mm., it is about twice the size of even the more advanced of the microspheric prolocula of individuals found in other species. It is not larger or more tumid than the other specimens of the same sample, whereas the microspheric individuals are larger than the megalospheric individuals, and in the lower forms, more tumid.

There is an interesting explanation of the discrepancy between the sketch of this specimen as first presented in 1932 and as presented here. In making a thin-section, one grinds it down to the middle of the proloculum on one side with little danger of losing the specimen. It is then turned over on the slide and ground to the required thickness. When it approaches the required thinness one is in danger of losing the section, especially if it is found necessary to reverse the specimen on the slide again. In the case of this

particular section, one does not realize the rarity of his find until he has practically completed the grinding of the first side. But in grinding down the other side to finish the section, he completes the section with less thinness than normally acceptable to avoid the danger of losing it. The result is that the poorer surface of the section lies under the thin cover-glass and the better side under the thick glass of the slide. Normally, one almost invariably works with the slide with the cover-glass up. The sketch made in 1932 and the photograph were made with the cover-glass up, the last sketch with the cover-glass down, which accounts for the discrepancy.

The rather unsatisfactory state of the thin-sections used in the accompanying illustrations is due to the fact of the obvious difficulties involving orientation and preservation of these characters, coupled with their extreme rarity, which leads to acceptance of a thicker section in most instances than would otherwise be admissible. The rarity of material may be judged somewhat by the fact that specimens showing the points discussed here numbered but fifteen in over four thousand thin-sections made by me. In order to make up for the difficulty in getting satisfactory results from unretouched photographs, camera-lucida pencil sketches of the early stages of some of the specimens are also included.

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RUDISTIDS FROM THE CRETACEOUS OF NORTHERN SANTA CLARA PROVINCE, CUBA

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ABSTRACT

Several faunas of rudistids collected in Cuba are reviewed, and the age of the sediments is ascertained to be Maestrichtian. Emended descriptions of *Barrettia monilifera* Woodward, *Biradiolites cubensis* Douvillé, and *Plagioptychus antillarum* (Douvillé) are given, and a new form, *Chiapasella cubensis*, is described.

The material here described was collected in the first half of 1933, when a party from the University of Utrecht, Holland, under the leadership of Prof. L. M. R. Rutten visited Santa Clara province, Cuba, for geological reconnaissance work.

Large and easily recognizable rudistids are a constant feature of the Upper Cretaceous layers in this part of the island and form one of the easiest ways of identification of these layers. There is, in previous literature, a slight controversy as to the exact age of different Cuban faunas which, for this region, can be settled now.

Douvillé (5) distinguishes five horizons. The Maestrichtian should be characterized by *Barrettia monilifera* and *Parastroma sanchezi*, the Dordonian by *Titanosarcolites giganteus* and *Biradiolites cubensis*, the Campanian by *Barrettia sparcilirata* and *Antillocaprina occidentalis*, the Santonian by small rudistids of the genera *Bournonia* and *Parabournonia* and by *Biradiolites lumbricoides*, and finally the Turonian by *Parabournonia hispida*, *Caprinula cubensis* and *Coralliochama antillarum*. Boissevain and MacGillavry (1) adopt a Senonian (probably Campanian) age for the strata from Pinar del Rio province, Cuba, containing *Barrettia sparcilirata* and *Chiapasella radiolitiformis*, and Palmer (9), without discussing the question, gives a Maestrichtian age for his Cuban rudistids.

At localities L. 483 and H. 156 (the letters L. and H. indicating the collectors, respectively, L. M. R. Rutten and H. J. MacGillavry) we found *Barrettia monilifera* and *Parastroma*. These localities are in the immediate neighborhood and same geological series as locs. H. 153, H. 160 and L. 485, where we found foraminiferal faunas of Maestrichtian age (10) with *Pseudorbitoides*, *Omphalocyclus* and *Lepidorbitoides*, so that the Maestrichtian age of these forms is established beyond doubt. At locality H. 550 *Pseudorbitoides* occurs with *Barrettia monilifera*, *Torreites sanchezi*, *Biradiolites cubensis*, *Parabournonia hispida* and *Chiapasella cubensis*, so that at least part of the forms considered by Douvillé to belong to older layers occur in the

Maestrichtian. The same can be said of locality H. 169, where *Barrettia* is found with *Biradiolites cubensis* and the form called *Coralliochama antillarum* by Douvillé, and about locality L. 543 where smaller forms of *Bournonia* and *Barrettia* occur together.

In short, all the rudistid faunas collected by us belong to the Maestrichtian. I have received through courtesy of the Bataafsche Petroleum My., however, a small collection of rudistids made by Dr. Tschopp from a point north of the road from Sagua la Grande to Quemado de Guiness, about five kilometers west of the first mentioned town. It consists of specimens of *Sauvagesia* that are not specifically determinable. As these forms yet possess a ligamental crest they might belong to older layers of the Upper Cretaceous, but the material is not sufficiently good to decide the question.

SYSTEMATIC DESCRIPTIONS

All specimens mentioned are in the collection of the Mineralogisch-Geologisch Instituut, Utrecht, Holland.

Genus TORREITES Palmer, 1933

TORREITES SANCHEZI (Douvillé)

Text-figure 4 *g*

Hippurites (*Vaccinites*) *sanchezi* DOUVILLÉ, *1927*, Soc. Géol. France, Bull., (4), tome 27, pp. 54, 55, pl. 4, fig. 1.

Torreites sanchezi PALMER, *1933*, Rev. Agricult. Habana, vol. 14, no. 15, 16, p. 100, lam. 7, figs. 1, 2, lam. 8, figs. 1, 2.—MACGILLAVRY, *1935*, Akad. Wet., Amsterdam, Proc., vol. 38, no. 5, pp. 563, 564.

My specimens agree well with the descriptions of previous authors. The angle between L and the line connecting A_{II}, P_{II} and *mp* varies from 20° to 30°. The canals in the left valve are not the equivalent of those found with the other Hippuritinae, as they are situated in the inner shell layer. They communicate freely with the living chamber but not with the outside since the outer shell layer (*"capa delgada imperforada"* of Palmer) is imperforate.

Maestrichtian, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, Cb. 1933, 1–8, Pa. 1935, 303.

Genus BARRETTIA Woodward, 1862

BARRETTIA MONILIFERA Woodward

Barrettia monilifera WOODWARD, *1862*, The Geologist, Oct., p. 372, 2 pl.—DOUVILLÉ, *1926*, Soc. Géol. France, Bull., (4), tome 26, p. 129, pl. 7, fig. 2.

Barrettia sparcilirata DOUVILLÉ, *1926*, Soc. Géol. France, Bull., (4), tome 26, p. 128, pl. 7, fig. 1.

The specimens vary strongly in size and number of rays. Other characters, however, such as the location and form of teeth and apophyses, are constant, as is also the moniliform character of the rays. Boissevain and MacGillavry (1, p. 1306) thought the specimens of *Barrettia sparcilirata* of Douvillé to be

Distribution of Species

Localities	H. 156	H. 196	H. 550	L. 483	L. 540	L. 543
Torreites sanchezi (Douvillé)	—	—	X	—	—	X
Barrettia monilifera Woodward	—	X	X	X	—	X
Barrettia multilirata Whitfield	—	X	—	—	—	—
Parastroma sp.	X	—	X	—	—	—
Biradiolites cf. *lameracensis* Toucas	—	—	—	—	X	—
Biradiolites cubensis Douvillé	—	X	X	—	X	—
Bournonia sp.	—	—	—	—	—	X
Parabournonia hispida Douvillé	—	—	X	—	—	—
Chiapasella cubensis Rutten, n. sp.	—	—	X	—	—	—
Plagioptychus antillarum (Douvillé)	—	X	—	—	X	—

nearly related to this form, but yet specifically distinct, for they have a smaller number of rays than the type specimens. Six of my specimens have the following number of rays: 39, 44, 55, 68, 80, 82. With their gradual variation they include the forms of Douvillé as well as the type specimens, and specific separation is unwarranted.

Maestrichtian, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, Cb. 1933, 32–40.

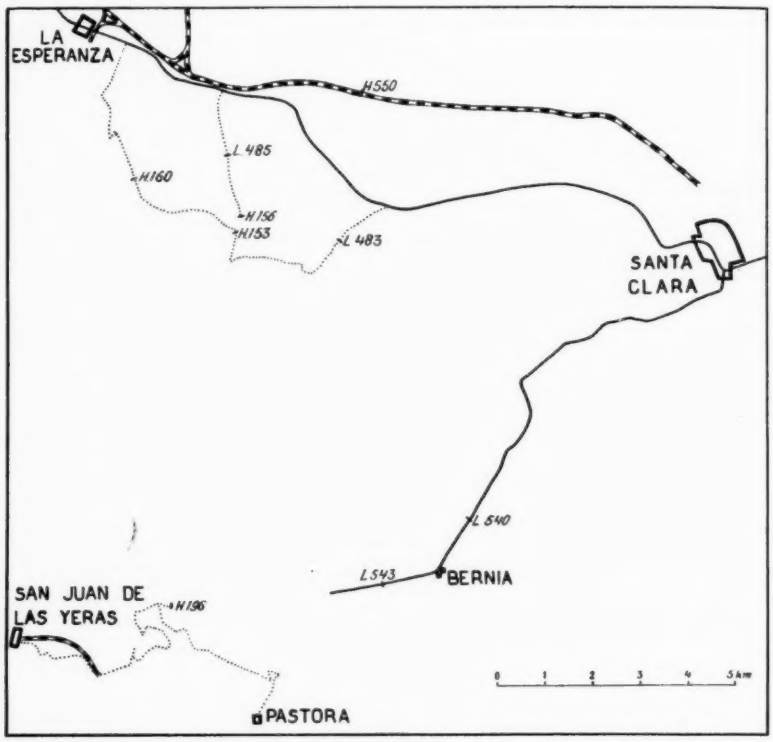

FIG. 1.—Sketch map of localities mentioned in this paper.

Genus BIRADIOLITES d'Orbigny, 1847

BIRADIOLITES cf. LAMERACENSIS Toucas

Text-figure 4 *i*

Biradiolites lameracensis TOUCAS, *1908*, Soc. Géol. France, Mém. 36, tome 16, pp. 110, 111, pl. 21, figs. 5, 5*a*.

A short, conical form is placed in this species. The right valve is about 9 cm. long with strong foldings on the posterior side. *E* and *S* clearly marked, with three ribs between them. Anterior side not folded. The place of the cardinal apparatus is indicated by the sockets of the inner shell layer of the right valve that correspond with the teeth of the upper valve. It is placed very high, the secondary cavity being small. The left valve is small and flat.

Maestrichtian, Santa Clara province, Cuba. Hypotype, Min.-Geol. Inst., Univ. Utrecht, Pa. 1935, 305.

BIRADIOLITES CUBENSIS Douvillé

Text-figures 2, 3 *a–j*

Biradiolites cubensis DOUVILLÉ, *1926*, Soc. Géol. France, Bull., (4), tome 26, pp. 129–131, text-fig. 1.

This fossil was described by Douvillé from one specimen, a poorly preserved right valve. We found more and better

material so I can emend his description. The species is very variable as to size and form, but some of its outer features are always discernible. The horizontal outline of the shell is roughly oval, the anterior and posterior sides being gently curved. The posterior side is entirely covered by sharp ribs and infoldings, *E* and *S* lying also on ribs and presenting an even surface that is only relieved by horizontal lines of growth. The number and size of the generally two or three ribs between *E* and *S* is variable. The anterior side shows no foldings. In vertical outline the shell is gently curved, convex at the posterior and plane at the anterior side. The right valve is invariably the larger, being commonly about four times the size of the left valve but in some cases the disparity is not so great. All ribs and also the siphonal bands pass without interruption from the right to the left valve. Horizontal sections show an almost perfectly oval living chamber, with the cardinal apparatus well up, and the secondary cavity a good deal the smaller. The teeth correspond with sockets formed by the infoldings of the inner shell layer of the lower valve. Douvillé gives P_{II} shorter than A_{II}. This is no constant character, however, as my drawings show. Moreover, owing to the slight curvature of the test it is not possible strictly to define a horizontal section. The cardinal apparatus has one striking and constant feature. In making different horizontal sections through the same shell one observes that in the

FIG. 2.—External view of *Biradiolites cubensis*, anterior side, strongly ribbed. Natural size.

neighborhood of the commissure both P_{II} and *mp* are drawn away from the periphery. Higher up the apparatus stretches outward again, to unite with the upper valve.

The species is certainly related to *B. lameracensis* but differs in its larger size, the form of the living cavity and its horizontal outline, which is oval, and by the last mentioned feature of the cardinal apparatus.

The curvature of the test together with the non-costate anterior side suggest that the animal lay on this side and not attached at the tip of the lower valve. According to Douvillé (3, pp. 417, 418) this indicates that the animal lived in deep water. For the Cuban specimens this certainly was not the case, as in several faunas we find this species together with orbitoids in reef-facies. A more acceptable explanation is that these forms are adapted to living in the surf, where a large plane of support and the curved posterior surface offering little resistance to waves are advantages.

Maestrichtian, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, Cb. 1933, 9–16, Pa. 1935, 306.

Genus BOURNONIA Fischer, 1887

BOURNONIA sp.

Text-figure 4*k*

This is a neat little form with strong ribs, those of *E* and *S* being exceptionally broad. The cardinal apparatus is high up and the teeth are connected by a bridge. I am not aware of any *Bournonia* with these characters of small size and strong foldings, but the material is insufficient to make sure statements.

Genus PARABOURNONIA Douvillé, 1927

PARABOURNONIA HISPIDA Douvillé

Text-figure 4*b*

Parabournonia hispida DOUVILLÉ, *1927*, Soc. Géol. France, Bull., (4), tome 27, pp. 55, 56, pl. 4, figs. 2, 3.

Embedded in hard limestone and only to be studied in sections are small rudistids of variable shape that are very similar to small forms of *Bournonia*. There is no trace of a ligament and the cardinal apparatus is not preserved. The shell shows clearly a denticulate structure which is the criterion for identification of the genus. The general size accords with that of *P. hispida* and therefore I have placed all specimens in this species, as the variations in form seem to be purely accidental. In the meantime, however, I am not satisfied that the genus is a valid one. The "*structure denticulée*" certainly is an easily recognizable feature, but in several specimens of *Biradiolites cubensis* we have found the same structure, not all over the shell, but locally. In my opinion this is intermediate between the striated and the cellular structure and should then not be a character of generic value. Douvillé (2, p. 23) comes to the same conclusion with regard to the genus *Radiolites* where he enumerates forms, "*normalement striées, sémistriées et réticulées presque tout entière.*" The forms then should belong to the genus *Bournonia* and the only reason for my continuing to name them *Parabournonia* lies in the fact that my material is too poor to decide whether the genus is valid or not; and in case it is not, whether the species

FIG. 3.—Sections of *Biradiolites cubensis*, ×0.5. *a–f*, Horizontal sections through the same individual. Starting with fig. *a*, lowest down, the tooth A_{II} is longer than P_{II}; in fig. *c* both teeth are united by a bridge; in fig. *e*, near the commissure, P_{II} and *mp* are drawn away from the periphery, at *y* with infoldings of the upper valve; fig. *f* shows *mp* in articulation with part of the left valve, sectioned at *x*. Figs. *g–j* represent similar sections through a second specimen, fig. *g* showing only two ribs between *E* and *S*, while fig. *j* shows P_{II} and *mp* drawn away from the periphery.

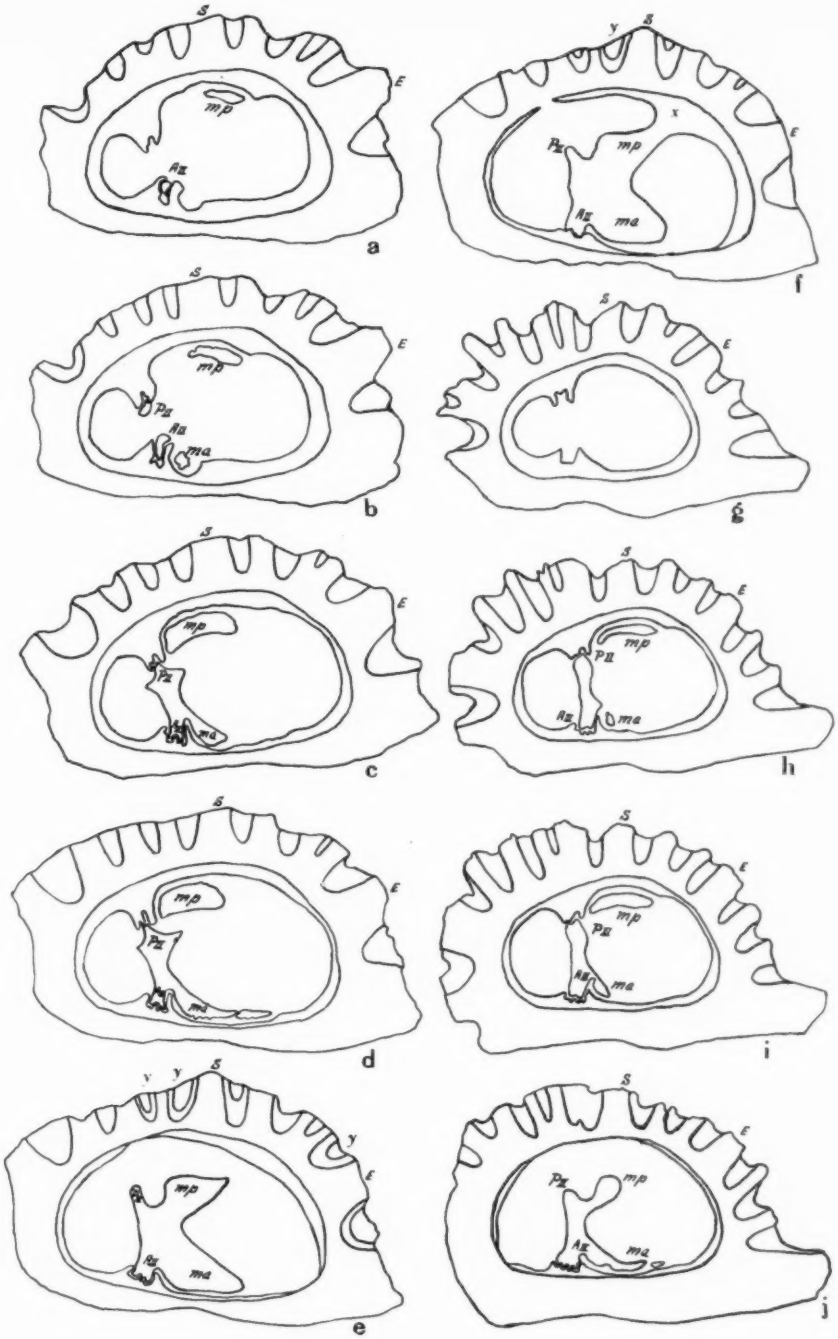

FIGURE 3.

is a valid one or perhaps synonymous with an older species of *Bournonia*.

Maestrichtian, Santa Clara province, Cuba. Hypotypes, Min.-Geol. Inst., Univ. Utrecht, Cb. 1933, 28, 29.

Genus CHIAPASELLA Müllerried, 1931

CHIAPASELLA CUBENSIS Rutten, n. sp.

Text-figures 4*a*, *e*, *h*, *l*

This species is rather variable in size and form. It is small, never attaining a height of 10 cm. The right valve is short-conical, the diameter being about as great as the height, and has several ribs. *E* and *S* lie on two adjacent ribs, but the number and size of the other ribs is variable. The position of *E* and *S* is clearly seen in a horizontal section, where there is a marked difference in the lines of growth, resulting in thick lines of calcite cutting through the ordinary cellular structure. This agrees with Müllerried (7, figs. 1–5), who places the siphonal bands of *C. radiolitiformis* on ribs. Boissevain and MacGillavry (1, fig. 6) for the same species place *E* and *S* on two of the infoldings. This cannot be right as there is nothing that distinguishes these particular two infoldings from the other ones. The present species has a number of infoldings, always more than one and less than sixteen. Their character differs from those described in *C. radiolitiformis* for they are much shallower and in most cases the cortical layers of both sides do not even meet, as in *radiolitiformis*, forming there a structure resembling a pillar of *Barrettia*. The cardinal apparatus consists of two teeth, connected by a bridge and two myophoral apophyses of which the anterior is very long and irregular in outline.

The left valve is convex with a low apex. The two ribs corresponding to *E* and *S* extend on the upper valve but there is no other ornamentation. The commissure is almost plane, only slightly dipping towards the posterior side. The canals have the same form as in the type species.

This species is to be recognized by its small size, conical form and the nature of the infoldings, together with their number which is intermediate between that of the two known species, *C. radiolitiformis* and *C. bermudezi*.

Maestrichtian, Santa Clara province, Cuba. Holotype, Min.-Geol. Inst., Univ. Utrecht, Pal. 1935, 304. Paratypes id. Cb. 1933, 22, 23.

Genus PLAGIOPTYCHUS Matheron, 1842

PLAGIOPTYCHUS ANTILLARUM (Douvillé)

Text-figures 4*c*, *d*, *f*, *j*

Coralliochama antillarum DOUVILLÉ, *1927*, Soc. Géol. France, Bull., (4), tome 27, p. 53, text-fig. 2.

This fossil was described by Douvillé from upper valves only and was reckoned to belong to the genus *Coralliochama*, as the author could distinguish two separate systems of canals in this valve. Mülleried (8, p. 178) drew attention to the fact that the structure of the canals differs from that in *Coralliochama*.

We found specimens with both valves. The right valve is long, straight, conical,

FIG. 4.—Structures of rudistids. *a*, *e*, *h*, *l*, *Chiapasella cubensis* Rutten, n. sp.; *a*, enlarged view of infolding (*s*, outer cortical layer, *t*, inner shell layer), ×3.8: *e*, horizontal sections of paratypes, showing strong variation, ×0.5; *h*, horizontal section of right valve of type specimen, showing cardinal apparatus, cellular structure of the shell, lines marking *E* and *S* and the infoldings, ×1.3; *l*, external view of anterior side of type specimens, ×0.7. *b*, *Parabournonia hispida* Douvillé, horizontal and slightly oblique sections of different specimens, ×0.5. *c*, *d*, *f*, *j*, *Plagioptychus antillarum* (Douvillé); *c*, *f*, enlarged view of left valve to show the form of the canals and the irregular cavities, ×2.3; *d*, external view of eroded specimen with straight, conical right valve with thin shell, and curved left valve with thick shell layer, canals of left valve indicated, ×0.6; *j*, horizontal section of left valve, showing position of canals and irregular cavities, the living cavities, ligamental crest *L* and part of the dental apparatus, P_{II} and *mp*, ×0.9. *g*, *Torreites sanchezi* (Douvillé), oblique section through shell of left valve, with outer imperforate layer, and with canals of inner layer opening into the living chamber (below), full size. *i*, *Biradiolites* cf. *lameracensis*, Toucas, horizontal section, ×0.5. *k*, *Bournonia* sp., horizontal section, ×1.8.

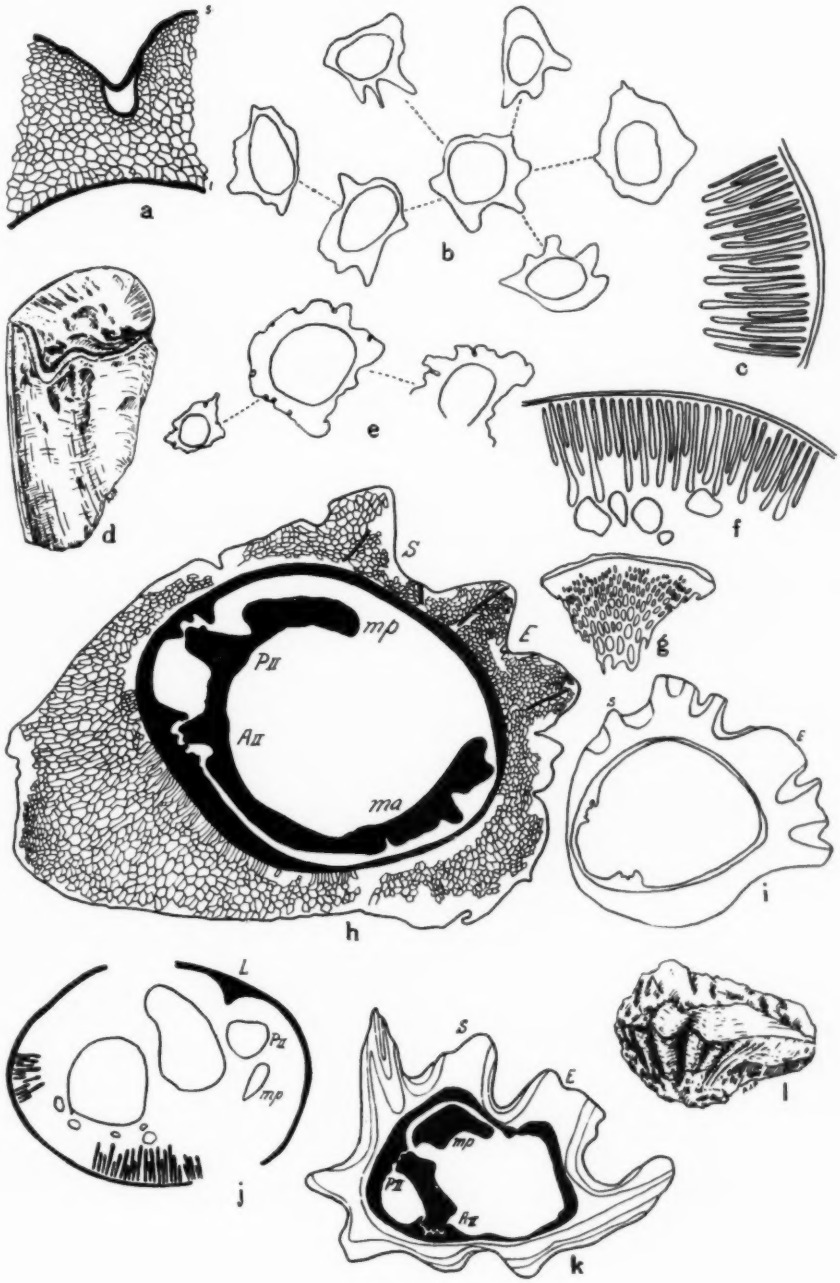

FIGURE 4.

and has a thin outer layer without canals, so that the species belongs to the genus *Plagioptychus*. The left valve is small, low and curved. The cortical layer is of varying thickness, thickest near the ligamental crest. In the inner shell layer canals are developed with the exception of the dorsal side of the test. The canals are of different lengths, the larger ones broadening toward the end. Besides these canals we see in various parts of the shell rounded irregular cavities, the second system of canals of Douvillé. They are distributed irregularly and are not to be confounded with the canals, as they are not continuous throughout the valve. This is best seen in different horizontal sections of the same individual.

The cardinal apparatus is badly preserved. P_{II} and *mp* are discernible, A_{II} and *ma* probably much smaller.

The species is characterized by its long, slender, conical right valve, which is not curved, and by the irregular cavities in the upper valve. The second character shows strong individual variation.

Maestrichtian, Santa Clara province, Cuba. Hypotypes, Geol.-Min. Inst., Univ. Utrecht, Pal. 1935, 307, Cb. 1933, 30, 31.

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PALEONTOLOGICAL NOTES

OSTRACODA OF THE GENUS *EUCYTHERE* FROM THE TERTIARY OF MISSISSIPPI

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In a recent number of this Journal, C. I. Alexander[1] recorded the occurrence of a species of the ostracode genus *Eucythere* from the Midway Eocene of Texas. The writer is here describing three additional Tertiary species from Mississippi; one from the lower Jackson Eocene, one from the Byram marl division of the Vicksburg Oligocene, and one from the Miocene (?) lower Chickasawhay member of the Catahoula formation. The Byram species, at least, is of rather wide distribution in the states east of the Mississippi River and should prove a good guide fossil.

Suborder PODOCOPA Sars

Family CYTHERIDAE Baird, 1850

Genus EUCYTHERE Brady, 1866

EUCYTHERE WOODWARDENSIS, Howe, n. sp.
Text-figures 1, 3, 7

Carapace moderately inflated, in side view subtriangular, the ventral margin being straight, the dorsal margin nearly so, the dorsal and ventral margins approaching each other at the subacute posterior end, the anterior end broadly and obliquely rounded. Greatest height in front of the middle at the angulate anterior cardinal angle. Viewed from above, the outline is lenticular, the anterior extremity being slightly sharper than the posterior. The left valve is larger than the right and overlaps it along the dorsal, posterior and ventral margins; the greatest overlap being at the anterior cardinal angle. Surface smooth, polished, semi-transparent, showing a number of large, normal pore canals. Viewed from the inside, the valves are deep, smooth, flanked by a wide marginal area, widest at the anterior end. The line of concrescence lies midway between the inner and outer margins around the posterior end and around a portion of the anterior end. The radial pore canals are very fine, widely spaced, but fairly numerous around the anterior end. Ten or more are visible around the ventral side, but none appear on the posterior end. The middle of the ventral margin of each valve bears a slight flange. The hinge of the left valve consists of an elongate sharp bar, separated from the dorsal margin by a faintly incised line. At either end of the bar there is a shallow socket just below the dorsal margin. The hinge of the right valve is much more delicate than that of the left and consists of a faint groove in the edge of the dorsal margin. The muscle scar pattern is characteristic of the genus and consists of an oblique row of four small spots, in front of which is a larger, crescent-shaped spot.

Dimensions of holotype No. 1101, from the Byram marl on the west bank of the Chickasawhay River, one-fourth of a mile west of Woodwards, Wayne County, Mississippi: Length 0.49 mm., height 0.30 mm., thickness 0.24 mm. Paratype No. 1099 (collected by B. W. Blanpied), a left valve from the Byram marl on Leaf River, 4½ miles southwest of Sylverina, Mississippi: Length 0.68 mm., height 0.41 mm.

This species is about the same size and shape as most species of *Cytheridea* and seems to replace that genus in many Byram marl samples. The writer has it in his collections from numerous localities from Vicksburg, Mississippi, on the west to Murder Creek, near Castlebury, Alabama.

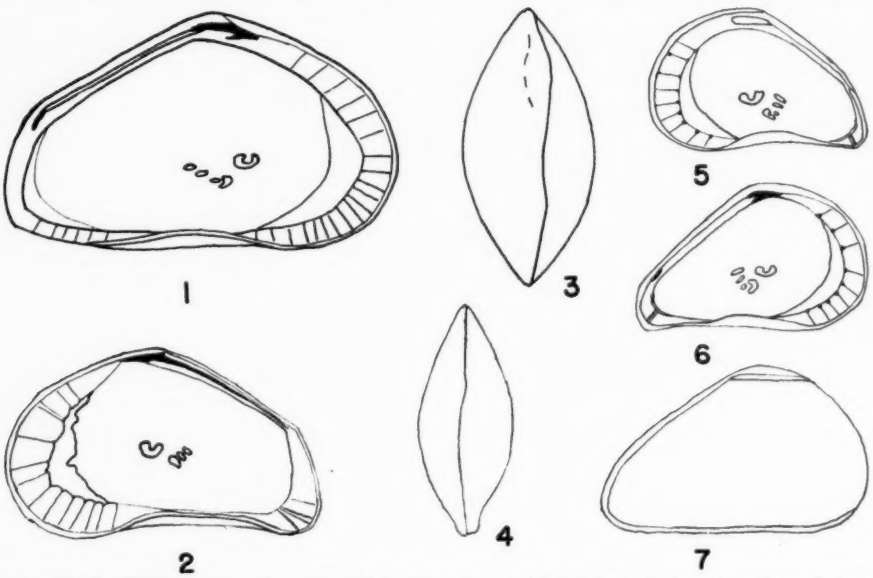
EUCYTHERE CHICKASAWHAYENSIS
Howe, n. sp.
Text-figure 2

Carapace in side view subtriangular, the an-

[1] Alexander, C. I., Ostracoda of the Midway (Eocene) of Texas: *Jour. Paleontology*, vol. 8, p. 227, pl. 33, fig. 15, 1934.

terior end being obliquely rounded, produced below. The ventral margin nearly straight, dorsal and ventral margins converging strongly toward the posterior, which is narrow and obliquely rounded. Greatest height just in front of the middle and greatest thickness just behind the middle. The surface is delicately sculptured with a coarse pattern of reticulations. These reticulations are more or less irregular except on the ventral slope where they tend to produce a series of longitudinal striations. There are a few widely spaced, small, normal pore canals. Viewed from the inside, the carapace is moderately deep, flanked by the marginal area, which increases in width from the posterior to the anterior end, widest in the lower part of the anterior end. The line of concrescence lies about midway between the inner and outer margins around the anterior extremity. There are about fourteen widely spaced, radial pore canals around the anterior end; on the posterior end there are three canals which radiate in a fan-shape from the posterior extremity of the inner margin and one single canal just above that. The hinge of the right valve consists of an elongate, narrow bar, separated from the dorsal margin by a faintly incised line. Above the anterior end of this bar there is a short, narrow socket. The muscle scar pattern consists of three oval spots in an oblique row, in front of which is a larger, heart-shaped spot.

Dimensions of holotype No. 1100 (material collected by B. W. Blanpied), from the lower Chickasawhay member of the Miocene Catahoula formation on the bank of Bucatanna Creek, approximately at the center of the SW. $\frac{1}{4}$ of sec., T. 8 N., R. 5 W., Wayne County, Mississippi: Length 0.54 mm., height 0.32 mm.



FIGS. *1, 3, 7—Eucythere woodwardensis* Howe, n. sp. *1*, Left valve; *3*, dorsal outline; *7*, latera view, right valve.
2—Eucythere chickasawhayensis Howe, n. sp. Right valve.
4–6—Eucythere lowei Howe, n. sp. *4*, Dorsal outline; *5*, right valve; *6*, left valve.
All figures approximately ×37.5

The description of the species is based on two right valves. It is closely related to *Eucythere woodwardensis*. If differs from that species in outline, in surface ornamentation and in shape of the muscle scars.

EUCYTHERE LOWEI Howe, n. sp.

Text-figures 4–6

Carapace delicate, slim, gracefully tapering from the anterior cardinal angle to the sub-

acute posterior. The hinge-line is straight with a very faint angulation at the posterior cardinal angle. Viewed from above the carapace tapers gracefully to either extremity. The ventral margin gently concave and the anterior end broadly and obliquely rounded. Greatest height at anterior cardinal angle; greatest thickness at about the middle. Surface smooth and polished, transparent and marked by a few large, widely scattered normal pore canals. Left valve slightly larger than the right and overlapping only at the anterior cardinal angle. Viewed from the inside, the valves are regularly depressed to the center, flanked by a marginal area, which increases in width from the posterior to the anterior end. Widest near the anterior extremity; the line of concrescence lies between the inner and outer margins on either end, being closer to the inner margin. There are a few delicate, widely spaced radial pore canals at the anterior end and three delicate, closely spaced canals at the posterior extremity. The hinge consists of an elongate, narrow, sharp, slightly sinuous bar in the left valve, at either end of which there is a narrow depression. In front of the anterior depression, the dorsal margin is thickened and projects strongly. The hinge of the right valve consists of two faint projections of the dorsal margin at the cardinal angles, between which points the dorsal margin is depressed and faintly grooved. The muscle-scar pattern consists of four spots in an oblique row, the ventral spot being arcuate. In front of this row there is a larger spot, which is more or less crescent-shaped.

Dimensions of syntypes No. 1111 (material collected by R. B. Grigsby), from the lower Jackson Eocene on the west side of Pachuta Creek, 6 miles south of Pachuta, Mississippi: Left valve, length 0.42 mm., height 0.23 mm.; right valve, length 0.42 mm., height 0.21 mm.; complete specimen, length 0.41 mm., height 0.23 mm., thickness 0.17 mm.

Named for Miss Louise Lowe, Librarian of the School of Geology, Louisiana State University.

MAKING PRINTS OF FORAMINIFERA

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Leiden, Holland

Print-making by means of collodion films is becoming more and more popular in biological and paleozoological research (1).

Dr. I. M. van der Vlerk was the first to adapt this method to foraminiferous rocks. He writes concerning it as follows:

In the last few years I have sometimes substituted for sections celluloid-preparations, similar to those used by Walton and Koopmans in palaeobotany, except that the preparations were not laid in Canada balsam, as Walton did, but simply placed between two glass slips. The best results were obtained by using "Durofix," an ordinary commercial article. The advantages of this celluloid method are: (1) duplicates or triplicates can be made; (2) a series of preparations can be made from which the whole foraminifera can be reconstructed; (3) it is not necessary to sacrifice a large amount of the material as is unavoidable with thin sections; and (4) it costs less, both in time and money. (2)

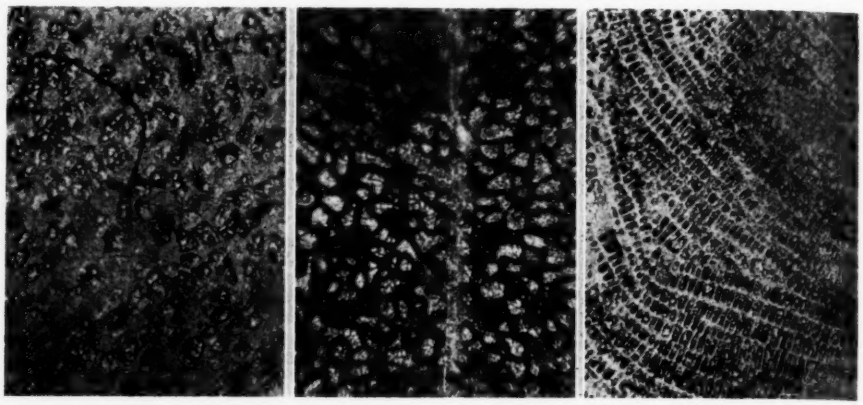
I made some experiments myself in the paleontological laboratory of the Delft University, with the following results.

I was most successful when using as solvent a mixture of 50 percent volume of acetone and 50 percent volume of amylacetate. In a solution of pure acetone the solvent evaporates too quickly, thus occasioning the formation of bubbles.

In making a print I used two solutions of different concentration, one of 1 gram of celluloid in 100 c.c. of solvent, with which to make the print itself, and a second one of 5 grams of celluloid in 100 c.c. of solvent to strengthen it.

To get a series of sections a special cement which does not dissolve in acetone is needed. The best results were obtained with brimstone. It is easy to handle and easily washed away with carbon-disulphide.

For making a series the process is as follows: The object is cemented on a strip of glass by melting the brimstone on the glass and putting the object upon it. Then after a moment when the brimstone has become hard, the fossil is ground and the surface burnished and stripped off simply. Now the grinding, burnishing, and etching can be repeated a little farther on, so that a series of sections at any desired distance from one another can be obtained. The method here described is illustrated by examples shown in Figure 1.



a *b* *c*

FIG. *1*—An example of sections in series, showing *Discocyclina papyracea* Boub. var. *javana* Verb., (*a*) near the top, (*b*) about halfway between the top and the equatorial plane, (*c*) in the equatorial plane.

etched with simple diluted HCl (1/10 N). The time needed for the etching depends upon the nature of the rock, but 1 to 1½ minutes is usually enough. The surface should be left to dry thoroughly, and then a thin layer of the first solution with 1 gram of celluloid should be poured upon it. As soon as this layer begins to grow opaque, a second one of the second solution should be poured upon it quickly, to prevent it dissolving and spoiling the first layer. Generally two layers of the second solution will do. After that one should wait for an hour or two until the celluloid is sufficiently dried to form a cohesive film which can be

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DR. CARL BURCKHARDT, 1869–1935

Carl Burckhardt was born in Basel, Switzerland, in 1869. He studied sciences, especially geology, in Switzerland, where one of his professors was the famous Albert Heim, who enthused Burckhardt to work in the Swiss Alps. This work resulted in his first geological publication and in his graduation as doctor of sciences.

After his graduation Burckhardt went to work for the Geological Service of Argentina, where he explored part of the mountains to the west, in territory of Argentina and Chile. The results in part were worked out by Burckhardt in München, Germany, where several publications were finished under the guidance of the famous stratigrapher and paleontolo-

gist, Prof. K. A. von Zittel. Zittel impressed Burckhardt very much, and on his recommendation Burckhardt went to work in the Geological Institute of Mexico, then under the directorship of José G. Aguilera. For thirteen years Carl Burckhardt worked in the field and office, his chief subjects of investigation being the Mesozoic stratigraphy and ammonites of several regions of Mexico. Although it should be mentioned that Dr. E. Böse during the same time made important contributions to the knowledge of the Cretaceous fossils and stratigraphy of Mexico, it can be said that Burckhardt laid the foundation for the stratigraphy of the whole Mesozoic of Mexico. The very important work of Burckhardt under the directorship of José G. Aguilera was suddenly interrupted in 1915, owing to the closing down of the Geological Institute. From then on Burckhardt lived as a private citizen in Mexico City. He never went to the field again, but he continued working on the Mesozoic ammonites and stratigraphy of Mexico, always from the broadest point of view. Zittel's spirit was with him always.

In 1930 Burckhardt, after eight years of study, organized his thorough knowledge of ammonites and stratigraphy in his very valuable "*Étude synthétique sur le Mésozoique mexicain*." This publication presents a synthesis of all that is known about the Mesozoic of Mexico, the detailed stratigraphy, the fossil content and the facies. This most important book brings the number of publications by Carl Burckhardt to 45. Afterwards he continued to work on the Mesozoic of Mexico, but was suddenly stopped by an illness which after a few days caused his untimely death, on the 26th of August, 1935, at the age of 66 years, 5 months.

During his lifetime few scientific honors were bestowed upon him. A few years ago, Burckhardt was made an honorary member of the Society of Economic Paleontologists and Mineralogists, of the Schweizerische Naturforschende Gesellschaft (Switzerland) and of the Sociedad Científica "Antonio Alzate" (Mexico).

Burckhardt lived a solitary life after the closing of the Geological Institute in Mexico. He had few friends, but I think we who have had the privilege of knowing him will never forget his personality. Economic geologists in Mexico whose work is based on stratigraphy, as in the search for oil, should not and will not forget Carl Burckhardt's fundamental work on the Mesozoic strata. In Argentina and Switzerland, too, his work has been of importance.

F. K. G. Müllerried, Mexico

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